The Engineer

LONDON, FRIDAY, OCTOBER 24, 1941

PUBLIC NOTICES

DARTFORD JOINT HOSPITAL COMMITTEE

APPOINTMENT OF LAUNDRY ENGINEER

The Committee Invite Applications for the APPOINTMENT of a LAUNDRY ENGINEER at the Infectious Diseases Hospital, Bow Arrow Lane, Dartford. Salary £250, rising by annual increments of £5 to £275. Candidates must have a knowledge of Merr Inman All-tension Boilers and only those need apply. The appointment will be subject to the Local Government Superannuation Act, 1937. Applications, in candidates' own handwriting, on forms to be obtained from me, should reach me by not later than Friday, the 7th November, endorsed "Engineer."

EUSTACE J. HOBBS,
Clerk.

Council Offices,
West Hill,
Dartford.
17th October, 1941. 7875

HULL EDUCATION COMMITTEE

MUNICIPAL TECHNICAL COLLEGE

Applications are Invited for the POSITION of LECTURER in CHARGE of the MARINE ENGINEERING SCHOOL to commence duties on the 1st January, 1942. Candidates should preferably hold the Extra First Ticket and have had some experience in teaching and coaching work. Salary £300 per annum, rising to £365, with additional pay for evening classes.

Particulars and application forms, which should be returned not later than Monday, the 3rd November, may be obtained from R. C. MOORE, Director of Education, Guildhall, Hull, on receipt of stamped addressed foolscap envelope. 7847

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS 1940 No. 877

RESTRICTION ON ENGAGEMENT ORDER

ASSISTANT MINE SUPERINTENDENT REQUIRED for Gold Coast, with experience in Tropics; age 30-40; salary £50 per month, free passage, quarters, servants. Details of experience and references.—Address, 7876, The Engineer Office. 7876 A

ASSISTANT MECHANICAL ENGINEER, with Mining Experience, in Tropics REQUIRED for Gold Coast; age 30-40; free passage, quarters, servants. Details of experience, references, and salary required.—Address, 7877, The Engineer Office. 7877 A

CHIEF INSPECTOR for Important Steel Foundry Casting in Mild Steel and High-grade Alloys. Applicants should have good metallurgical knowledge and experience in steel foundry practice. Permanent position and good salary offered to the right applicant.—Address, 7866, The Engineer Office. 7866 A

ENGINEER, with Good Qualifications and practical experience to manage and take charge of the development and maintenance of a large wire netting and galvanising plant. Applicants need not have specialised experience provided they have good mechanical and technical qualifications with knowledge and experience of heavy machine design and modern workshop practice. The position offers scope and permanency to the right man and is of national importance. Strict confidence will be observed.—Apply, Box No. 3, W. S. Crawford, Ltd., 233, High Holborn, W.C.1. 7864 A

MAINTENANCE MANAGER.—A North-West Firm wish to APPOINT MANAGER for their extensive Maintenance Department dealing with thousands of customers' machines. Applicant must have knowledge of Engineering and Extensive Experience in Handling of Large Works or Maintenance Department. Exceptional progress can be made by keen and efficient man.—Write, giving age, salary, and full details previous experience, and photograph if possible, to 7821, The Engineer Office. 7821 A

The Engineer

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THE FACT that goods made of raw materials in short supply owing to war conditions are advertised in this paper should not be taken as an indication that they are necessarily available for export.

SITUATIONS OPEN

MANAGING DIRECTOR REQUIRED for Company (subsidiary of important old-established firm) manufacturing products of increasing importance to industry; high Engineering Qualifications and Managerial Experience essential. Only those commanding four-figure salary will be considered.—Address, P3561, The Engineer Office. P3561 A

SALES ENGINEER REQUIRED with Knowledge of Marine and Industrial I.C. Engines and Installations, also capable of preparing estimates and publicity. Some electrical experience essential. Scheduled firm. Replies in confidence.—Address, 7867, The Engineer Office. 7867 A

SITUATIONS OPEN

SHEET METAL and PRESS SALES ENGINEER, able to Discuss with Customers and Quote against their inquiries.—Write, stating age, full particulars of experience, and salary required.—Address, P3606, The Engineer Office. P3606 A

THE Post You Are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing Your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for a cost of Four Lines, 4s.; 1s. for each Additional Line. There is no better way of covering so large a field for such a small charge.

SITUATIONS WANTED

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CHARTERED CIVIL ENGINEER, Middle-aged, with wide experience office and outdoors, including large industrial buildings, railways and docks, now holding Government post, DESIRES CHANGE. Min. salary £500 p.a.—Address, P3607, The Engineer Office. P3607 B

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COMPETENT ELECTRICAL MECHANICAL ENGINEER, A.M.I.E.E., age 43, DESIRES RESPONSIBLE POSITION; extensive experience, lay-out, installation, and maintenance of power plant in large works; good organising ability; salary £600.—Address, P3611, The Engineer Office. P3611 B

ENGINEER (42), SEEKS RESPONSIBLE POST. Has held positions from Chief Draughtsman to Technical Director in heavy engineering. Extensive experience, home and abroad, in design, estimating, production and sales, both executive and technical. Accustomed control staffs. B.Sc. Degree, Glasgow University. Free short notice owing to export restrictions. Scottish appointment preferred, but not essential.—Address, P3577, The Engineer Office. P3577 B

EXPERIENCED ENGINEER, A.M.I.C.E., M.I.M.E., DESIRES APPOINTMENT duration of war. Recent experience, railway engineering, earthworks, large factories.—Address, P3592, The Engineer Office. P3592 B

IF the Man You Are Seeking is Not Amongst those Advertising in this Column, a Small Announcement in the "Situations Open" Column will Quickly and Economically Produce the Right Selection of Applicants, at the same time Eliminating Waste of Effort, Waste of Time, and Waste of Opportunity. The charge is Four Lines or under, 4s.; each Additional Line, 1s.; Box Numbers, 6d. extra, which includes despatch of all replies.

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CLASSIFIED ADVERTISEMENTS CLOSE FOR

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The Engineer

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This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next date, December 26th.

ADVERTISEMENTS.

The Charges for Classified Advertisements are 1/- per line up to one inch—minimum charge, 4/-: those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
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Teleg. Address,
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SITUATIONS WANTED

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MECHANICAL and ELECTRICAL ENGINEER, over military age, but exceptionally fit and adaptable, qualified designer with Honours Degrees, widely travelled, British subject, with varied and successful career in handling the technical and commercial aspects of big business as manager, organiser, and consultant, is OPEN to UNDERTAKE MORE WORK; also FULL-TIME JOB at home or abroad. Please write.—Address, P3602, The Engineer Office. P3602 B

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RESIDENT ENGINEER (32), Now Completing important Ministry of Supply contracts, and previously Air Ministry works, is NOW AVAILABLE to ACCEPT RESPONSIBLE POSITION on contract or other work of national importance. Well experienced both in constructional work and installation of mechanical plant, combined with sound knowledge of business.—Address, P3600, The Engineer Office. P3600 B

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PRACTICAL WATCHMAKER DESIRES PARTNERSHIP or SHARE in Small Factory making instruments. Active invest £500.—Address, P3576, The Engineer Office. P3576 C

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CHEMICALS.—FIRM of INDUSTRIAL MANUFACTURING CHEMISTS is willing to CONSIDER SUGGESTIONS for the MANUFACTURE and/or SALE of CHEMICAL PRODUCTS used in the engineering, plastic, paint, &c., industries.—Address, 7873, The Engineer Office. 7873 I

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ENGINEER, Victoria Street, S.W.1, with wide technical and commercial experience, DESIRES LONDON REPRESENTATION of Provincial Firms. Speciality, all power and allied plant.—Address, P3584, The Engineer Office. P3584 D

NORTHERN IRELAND.—TECHNICAL SERVICES and OFFICE FACILITIES at the DISPOSAL of Firms engaged in Supply of Material and Plant for urgent contracts and of national importance.—Address, P3594, The Engineer Office. P3594 D

PATENTS

IT is DESIRED to SECURE the Full COMMERCIAL DEVELOPMENT in the United Kingdom of BRITISH PATENT No. 470,911, which relates to "Roller Bearings," either by way of the GRANT of LICENCES or otherwise on terms acceptable to the patentees.—Interested parties desiring copies of the patent specification and further particulars should apply to STEVENS, LANGNER, PARRY & ROLLINSON, 5 to 9, Quality Court, London, W.C.2. 7869 H

THE PROPRIETORS of BRITISH PATENT No. 491,334, dated May 4, 1937, relating to "Improvements in Winches," are DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—Inquiries to SINGER, EHLERT, STERN & CARLBERG, Chrysler Bldg., New York City, N.Y., U.S.A. 7887 H

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FOR SALE, the Latest NEW AUTOMATIC WIRE FORMING MACHINE, for a variety of forms at high speed; built to British standards, accuracy, accessibility, adaptability. Nearest offer £650.—Address, P3605, The Engineer Office. P3605

For continuation of Small Advertisements see page 64

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A Seven-Day Journal

A Month's Air War

According to information recently made available by the Air Ministry, it is shown that the cost to the R.A.F. of its great offensive over Germany and occupied territory for the month of September was only a sixth of that suffered by the Germans in their air assault on this country during the same month last year. Britain's total losses were 173 aircraft for September, 1941; Germany's total losses for September, 1940, were 1089. During the same period the R.A.F. destroyed a total of 134 enemy aircraft. In all air operations, offensive and in the defence of this country, in the Middle East and in Russia, we destroyed 196 enemy aircraft. Our total losses on all fronts amounted to 204 aircraft. One hundred and forty-eight bombing attacks were made by the Royal Air Force on all fronts against 82 Axis targets during the month. During the same period our aircraft sank or damaged 53 enemy ships in the North Sea and off the Atlantic coast, while in the Mediterranean a further 48 were sunk or damaged. This makes a total of 101 ships or approximately 3½ ships a day sunk or damaged during September. A new feature of the attacks on shipping was the use of the four-cannon and twelve machine gun "Hurricanes," which, by concentrated fire power, have succeeded in setting on fire or sinking 12 enemy vessels.

Individual Reservation to Supersede Group Reservation

In a speech which he delivered at Stoke-on-Trent on Saturday, October 18th, Mr. Ernest Bevin, the Minister of Labour and National Service, announced that individual reservation would shortly be introduced in place of the method of group reservation which had hitherto been adopted. He said that while the system of group reservation had undoubtedly had a great and steadying influence on man power and war production, the time had now arrived when there must be national service on a more intense scale. The Ministry, he said, must find out not only what job a man was doing now, but what job he had done before, so that his services could be utilised to the fullest extent. Stricter arrangements would be made, Mr. Bevin announced, to see that those who were called up would be placed in positions in which they could give their best service to the nation. In order, he said, to give effective aid to Russia and at the same time to keep our own British Forces properly equipped, British factories engaged in war production would have to increase their outputs during the winter months by 30 or 40 per cent.

Government Road Haulage Scheme

On Monday, October 20th, the Minister of War Transport made the following announcement with regard to the Government road haulage scheme. The objects laid down by the Minister as the essential features which on grounds of national policy any scheme must embody are briefly to provide a fleet of vehicles under continuous Government control, and to arrange through one channel at least a considerable part of the long-distance road movement of Government traffic or other national requirements. After consultation with the Road Haulage (Operations) Advisory Committee, the original plan has been modified by the embodiment of suggestions by the Committee, providing for additional vehicles to be available on call, at short notice, to meet emergencies and for a complete partnership with the industry in the operation of the scheme. The necessary organisation will be put into force as speedily as possible. It will consist of a Ministry organisation covering the country, divided into six divisions, and as a first step subdivided into fourteen areas. This organisation will control the traffic and movement operations of the fleet of vehicles above-mentioned, which will be under continuous control, and it will act as a clearing house for traffic which the Minister accepts; an organisation set up and managed by the industry alongside the Minister's organisation which will allocate the traffic which is passed to it by the Ministry's organisation; and a series of "defence lines" to meet emergencies and consisting of vehicles belonging to carriers and others who agree to place them at the Minister's disposal at short notice. Rates and conditions of hire, conditions of carriage, insurance, and all necessary working arrangements have been agreed and will shortly be available. Information as to the manner in which they may participate in this comprehensive scheme, in one way or another, will be made available to the industry at an early date through the Ministry's Regional Organisation, the associations of the industry and the Press. The intention of the Minister and the Advisory Committee is that the Minister and the industry shall co-operate to the fullest extent in a spirit of complete partnership in this effort to evolve a better use and control of goods road transport during the period of the national emergency.

Colliery Explosion in Yorkshire

It is with regret that we have to record the death of six colliery rescue workers in an explosion which occurred in Bullcroft Main Colliery, near Doncaster, at shortly after 3 a.m. on Sunday morning last, October 19th. Bullcroft is one of the six collieries belonging to Doncaster Amalgamated Collieries, Ltd., and the explosion occurred about 2 miles from the bottom of the shaft in the west district of the pit. Recently the management had been dealing with a case of heating found in an airway about 130 yards from the coal face. The place had been lined with sand and steel plating and the operation was apparently successful. On Saturday, however, following upon the reversal of an air current, inspection by Mines Inspectors and the colliery officials showed that further attention was necessary. A combined rescue party made up of teams from Bullcroft and Brodsworth collieries, equipped with breathing apparatus, went into the pit to restore normal conditions. The position was gradually improved and it was decided early on Sunday morning to re-establish normal ventilation. Shortly afterwards an explosion took place, and was accompanied by heavy falls of roof. Six of the rescue team were able to escape, but three others were caught by the blast from the ignited gas. Three other men are presumed to be underneath large falls of roof. The effect of the ignition was felt 650 yards from the scene of the explosion and many ventilation doors were blown open. In order to prevent any likelihood of further danger to rescue workers it was decided, after full and careful investigation by representatives of the management, the Yorkshire Mineworkers' Association and the Mines Inspectorate to seal off the affected part of the colliery.

Institution of Electrical Engineers and Post-war Planning

The Council of the Institution of Electrical Engineers has set up a Post-war Planning Committee, under the chairmanship of Mr. J. R. Beard. Other members serving on the Committee include Sir Noel Ashbridge, the President, Col. Sir A. Stanley Angwin, Dr. P. Dunsheath, Mr. V. Z. Ferranti, Dr. A. P. M. Fleming, Sir George Lee, Mr. E. Leete, Professor S. Parker Smith, Mr. Johnstone Wright, and Mr. H. T. Young. Its terms of reference are:—To study post-war planning in electrical engineering with the object of making recommendations to the Council from time to time, and in particular to consider and report on post-war developments in regard to education, training and personnel; fundamental and applied research; electricity supply, distribution and installation; production, manufacture and employment; telecommunications, reconstruction and development; the general policy of the Institution towards problems of post-war reconstruction and development, including any desirable changes in the structure and machinery of the Institution and of its public relations; and problems of standardisation and design. The Committee has power to co-operate, where desirable, with other bodies and persons carrying out similar duties. With the approval of the Council, the Committee, after a preliminary study of the field, has appointed sub-committees for the closer investigation of the problems coming in the first six sections above enumerated. The section dealing with standardisation, the seventh, is under discussion by the main Committee. It is intended to set up panels to assist the sub-committees in their work where desired, and the section dealing with electricity supply, distribution and installation has already set up six such panels, dealing with the more important aspects of the sub-committee's work. With a view to ensuring that the closest possible contact should be maintained with the other leading engineering institutions on the subject of post-war planning, it has been decided to set up a Joint Co-ordinating Committee, consisting of two representatives from each of the Institutions of Civil, Mechanical and Electrical Engineers. In addition, close *liaison* is maintained with the Minister of Works and Buildings, who has shown approval of and interest in the work of the Post-war Planning Committee.

Control of Building Materials

On Monday, October 20th, the Controller of Roofing, the Ministry of Works, announced further changes in the supplies of materials now controlled by the Department. While roofing slates are releasable by the quarries only for repairs necessitated by enemy action, essential maintenance work, and buildings of national importance, and these regulations still apply in general, the absence of enemy action on a large scale has permitted the temporary release, as from Wednesday, October 1st, 1941, and until further notice, of roofing slates of sizes 14in. and downwards, but the scarcity of the larger sizes still makes control over these materials essential. The 4½in. slates used for dampcourses are not subject to control. Certificates for the supply of slates should be forwarded by merchants to the secretaries of groups of quarries, as follows:—Mr. W. C. Oliver, Welsh Slate Quarries Regional Committee, Port Penrhyn, Bangor, North Wales; Mr. G. T. Setchell, Cornish Slate Quarries Regional Committee, Delabole, Cornwall; and Mr. L. R. Robinson, Westmorland Regional Slate Committee, Martin's Bank Chambers, Keswick, Cumberland. The output of the Scottish slate quarries is not controlled. Plasterboard is in short supply, and may not be used for blacking-out windows or any other non-essential purpose whatsoever. Supplies of wallboard and wood wool slab are now controlled. Some change has been made with regard to the supply of asbestos cement goods, and arrangements have now been made whereby those merchants who normally secured their supplies from asbestos cement manufacturers may, from October 1st, do so without the production of the Form M. Roofing felt has been released, and may now be purchased by the consumer without formality. The control of glass substitutes in the near future is probable. The schedule issued by the Ministry also gives particulars of other building materials which are controlled by the Director of Cement, the Director of Bricks, the Ministry of Supply, Iron and Steel Control, the Non-ferrous Metals Controller of the Ministry of Supply, and the Timber Controller of the Ministry of Supply. A list of the building commodities not under control by the Ministry of Works is also given.

EVOLUTION OF DESIGN OF FIRST QUEBEC BRIDGE

(For description see opposite page)

PLAN OF BRIDGE SUBMITTED TO DOMINION GOVERNMENT, JANUARY, 1898

THE PHOENIX BRIDGE COMPANY'S DESIGN ACCOMPANYING TENDER, FEBRUARY, 1899

FINAL DESIGN AFTER ENLARGEMENT OF SPAN BY MR. COOPER

Historic Accidents and Disasters

No. VII

(Continued from page 180, September 19th)

The First Quebec Bridge.—Part I

SOME seven miles above Quebec the water surface of the St. Lawrence narrows to a width of about half a mile. On the left or north bank the land rises fairly abruptly to a height of 160ft. or so. On the right bank there is a margin, about 450ft. wide, of flat low-lying ground and then a steepish rise to the same height as on the north side. For two-thirds of the channel width the river has a depth exceeding 100ft., the greatest depth, 200ft., occurring close to midstream. The river bed consists of a gravel, boulder and sand formation overlying a red and grey shale bed rock.

To the engineer the site seems to be one at which Nature intended a bridge to be built. To the superstitious, however, the history of the efforts made to build one at it might suggest the opposite conclusion. The modern visitor to Canada as he sails up river, on the last day of his voyage, from Quebec to Montreal, passes at the site beneath a vast cantilever structure which may in truth be described as a monument to man's persistence in the face of recurrent adversity. One great bridge was here begun in the early years of this century. It was more than half completed when, in August, 1907, the whole of the structure erected on the south side collapsed suddenly and completely. Seventy-five of the men engaged upon it at the time lost their lives. The *débris* was duly cleared away and a new design prepared. The work of construction had reached its final stages when, in September, 1916, the suspended span, while being hoisted into position, slipped from its lifting tackle and fell into the river with the loss of thirteen lives. The construction of a new suspended span was greatly impeded by the prevailing war conditions, but it was eventually accomplished and in August, 1919, the bridge was formally opened by H.R.H. the Prince of Wales (the Duke of Windsor).

Bridge building activities at the site thus covered from first to last a period of nearly twenty years. The history of the project, however, extends over a much longer time. In 1852 the citizens of Quebec advocated the construction of a bridge across the St. Lawrence at or near their city in order that communication by rail and road might be established with the Maritime Provinces and the United States Atlantic seaboard, thereby freeing their trade from the annual restriction imposed by the freezing of the river. Plans were prepared for a suspension bridge to carry both railway and highway traffic, but nothing further was done. In 1882 Mr. Baby, of Quebec, obtained a charter to construct a bridge across the river. A design for this bridge, a cantilever structure with a main span of 1442ft., was prepared by Messrs. Light, Brunlees and Claxton Fidler, but once again nothing came of the scheme. In 1887 the Quebec Bridge Company was incorporated and given powers to build a railway bridge—with facilities also for passenger and vehicular traffic—across the river, the work to be begun within three years and completed within six. For the next ten years the scheme remained in abeyance except for a periodical renewal of the company's charter and a progressive extension of the date specified for the completion of the structure.

In 1897 the Quebec Bridge Company, although still embarrassed, as it had been from the first, by lack of funds, felt itself to be in a position to take at least the first step towards achieving its object. In April of that year the company, following a report made to it by its chief engineer, Mr. E. A. Hoare, finally decided upon the site which the bridge was to occupy, the so-called Chaudière site, described in our opening paragraph. In the following June, when the American Society of Civil Engineers held its annual convention at Quebec, the company invited some of the visitors to inspect the site and study the proposed work. It cannot be denied that at that date and for several years afterwards there were many engineers who looked askance at the proposition to build a bridge across the St. Lawrence at the selected point and that their views found an echo in financial circles. Among the visitors to the site in the summer of 1897 there were, however, two men who from the first had faith in the scheme and took much interest in it—Mr. J. S. Deans, chief engineer of the Phœnix Bridge Company, of Phœnixville, Pennsylvania, and Mr. Theodore Cooper, consulting engineer, of New York. Within a week of the visit Mr. Deans wrote to Mr. Hoare and told him that Mr. Cooper would be glad to give the Quebec Bridge Company the benefit of his extended experience in bridge building. At or about the same time Mr. Deans obtained from Mr. Hoare a profile of the river crossing at the site and other general information for the purpose of preparing a tender for the work should his company be asked to submit one. On receipt of these particulars the Phœnix Company went actively to work. By the end of November it had completed a first preliminary general plan for the bridge. That plan showed a cantilever bridge with a span of 1600ft. between the pier centres and a clear height of 150ft. above high-water level. The lower chords of the cantilever and anchor arms were straight.* To improve the artistic appearance of the bridge the design was modified to the extent of curving these chords. This apparently minor point is worthy of note, because as finally designed and constructed the bridge had curved lower chords and because its collapse during erection was traced to the faulty design and failure of the lower chords of the anchor arm.

The modified design was completed by December 7th, 1897, and sent to Mr. Hoare. Early in 1898 the Quebec Bridge Company sought the Canadian Government's approval of the plans and site of the proposed bridge. The plans submitted were dated January 13th, 1898, and were signed by Mr. S. N. Parent, Mr. U. Barthe, and Mr. E. A. Hoare, the chairman, secretary, and chief engineer respectively of the Quebec Bridge Company. They were identical with the plans dated December 7th, 1897, prepared by the Phœnix Bridge Company. An Order in Council approving the plans and the site was issued on May 16th, 1898.

During these preliminary design stages Mr. Theodore Cooper does not appear to have assisted the Phœnix Company in any way. The actual designing work was carried out by Mr. P. L. Szlapka, the Phœnix Company's chief designing engineer. Mr. Szlapka's training consisted of a seven-years' classical course at a German college, followed by a four years' general engneering course at the Royal Polytechnic School, Hanover. He entered the Phœnix Company's service in 1880, spending his first six years in the drawing-office and then entering the designing department. He was responsible for the designs of a number of bridges erected by his company from 1888 onwards, but only one of them, that across the St. Lawrence at Cornwall, Ontario, had been of the cantilever type, and its main span had not exceeded 840ft. These details of Mr. Szlapka's training and experience are of interest because the design of the chords which failed was his work, and their failure was attributed to grave errors which he made in the course of it.

To return to our narrative, we have next to record that following the Government's approval of the plans and site of the proposed bridge, Mr. Hoare, in conjunction with Mr. R. C. Douglas, bridge engineer to the Government's Department of Railways and Canals, prepared a specification of a general nature suitable for calling for tenders. In September, 1898, circulars were issued inviting tenders for the construction of a cantilever bridge at the Chaudière site, in accordance with Mr. Hoare's specification. Any firm tendering for the work might, if it so desired, submit plans for a suspension bridge, in which case its tender was to be accompanied by an appropriate specification.

Tenders for a cantilever bridge with a channel span of 1600ft. were received in due course from the Dominion Bridge Company, Montreal, the Keystone Bridge Company, Pittsburgh, and the Phœnix Bridge Company. The Union Bridge Company, New York, submitted a tender for a stiffened suspension bridge of 1800ft. span. In addition, the Dominion and Phœnix companies submitted alternative tenders for stiffened suspension bridges with spans of 2000ft. and 1800ft. respectively.

The date for the receipt of the tenders was March 1st, 1899. Shortly before that date the Quebec Bridge Company felt it would be desirable to appoint a consulting engineer to examine and report upon the plans and tenders received in response to its circular. The names of six prominent engineers were considered. The outcome was that Mr. Cooper was invited to undertake the work. He accepted the offer and all the plans and tenders were sent to him for his consideration. On June 23rd, 1899, Mr. Cooper reported to the Quebec Bridge Company that he found the Phœnix Company's cantilever design "an exceedingly creditable plan from the point of view of its general proportions, outlines, and constructive features," that it was designed in accordance with the Quebec Bridge Company's specification, and that the tender accompanying it was the lowest in price.

The history of the project, as we have so far traced it, contains several features which can certainly be described as unusual, and as the narrative proceeds others still more unusual will emerge. The reader will be placed in a better position to understand the story of the first Quebec bridge if at this point we sketch briefly the characters of two of the principal actors in it—Mr. Hoare and Mr. Cooper. In the contrasting personalities of these two men we can find the explanation of much that would remain obscure if we were not acquainted with them.

Mr. Edward A. Hoare, M. Inst. C.E., before joining the Quebec Bridge Company as its chief engineer, had had about thirty-five years' experience in Canada, on railways principally, and on marine works and water

* The Forth Bridge has two main spans, each measuring 1710ft., with a clear height of 150ft. The lower chords of the cantilever and anchor arms are curved.

supply projects to a lesser extent. In the course of his railway work he had designed, supervised, or been responsible for the construction of a number of bridges, all of an ordinary kind, of wooden, steel truss, or girder construction, most of them single track, and none of them with spans exceeding about 200ft. He had a high reputation for integrity, good judgment, and devotion to duty, and was well known to the citizens of Quebec. There was, however, nothing in his record to indicate that he had the technical knowledge requisite to direct the erection of a structure equalled only by the Forth Bridge, and in some respects surpassing it. The circumstances leading up to his appointment as chief engineer to the company are not known, but it is on record that while he served it faithfully and to the best of his ability, the directors at an early date realised that he was not competent to control the work. Nevertheless, to the end they continued to give him the position, powers, and emoluments of the office of chief engineer. He considered himself to be in general control of the construction and to have everything under his jurisdiction, but on repeated occasions he showed an obvious disinclination to assume the responsibilities properly pertaining to his office and an equally obvious inclination to seek and be guided by the opinions of others. His subordinates, while they had the highest personal regard for him, did not seek his advice when difficulties arose. They turned instead to Mr. Cooper.

Mr. Cooper's appointment in March, 1899, as consulting engineer to the company was limited to the duty of examining the plans submitted by the tendering firms and reporting upon them. In May, 1900, he received an extended appointment to act as the company's consulting engineer during the erection of the bridge. In that capacity his strict duties were to examine, correct, and approve the plans prepared by the contractors, and to give Mr. Hoare engineering advice when requested. In practice, however, he went far beyond any such relatively narrow interpretation of his duties. He modified Mr. Hoare's original specification in a manner which was to prove largely instrumental in bringing about the disaster, advised and secured the alteration of the main span length from 1600ft. to 1800ft., appointed and instructed the principal inspectors at the bridge, and in the contractors' shops, and received routine reports from them, held direct communication with the contractors, and in many other ways assumed the duties of chief engineer as well as those of consulting engineer. Mr. Hoare became practically an executive officer, acting in all technical matters under Mr. Cooper's direction. He did not find his position intolerable. He does not appear to have realised even that it was anomalous.

The Royal Commissioners who subsequently inquired into the disaster reported that they were unable satisfactorily to determine the respective duties of Mr. Hoare and Mr. Cooper. "The impression left with us," they wrote, "is that throughout the work Mr. Cooper was in the position of a man forced in the interests of the work to take responsibility which did not fully belong to his position and which he was not authorised to take and that he avoided the assumption of authority whenever possible." With this view of the situation the evidence provided in the Commissioners' own report does not always seem to be in full agreement. It is at least certain that anyone who to-day reads the Commissioners' report can derive from it the basis of quite a different impression. Mr. Cooper was an elderly man, rapidly approaching seventy and of such infirm health that he was only rarely permitted to leave New York. His fame as an engineer was great, but he was still ambitious. On his own admission he greatly desired to build the Quebec bridge as his final work. His interest in the project was aroused at an early date, in the summer of 1897, as we have said, when the American Society of Civil Engineers visited the selected site. We need not speculate on the manner in which he came to be selected for the preliminary task of examining and reporting upon the plans and tenders received by the company in 1899. His reputation was such that we can accept his selection as reasonable and natural, and dismiss any suggestion that undue influence was exerted to secure him the appointment. This early official connection with the scheme doubtlessly served to increase his desire to take a prominent part in its fulfilment. In 1900, when he was offered the position of permanent consulting engineer to the company, he accepted the post in spite of the fact that the remuneration attached to it was inadequate and that no provision was made for providing him with, or paying the salaries of, a staff adequate to the responsibility of the duties which he would be required to undertake.

In Mr. Hoare's compliant nature he found no source of opposition or of any rivalry which would deprive him of the fame of being the chief person responsible for the construction of the bridge. Later on, in 1903, when the threat of a rival appeared, he took vigorous and successful action to nullify it. The Canadian Government by that date had undertaken to subsidise the Quebec Bridge Company and to protect itself sought to appoint a competent and independent bridge engineer to examine from time to time the detail drawings of the bridge and to approve or correct them as might be found necessary. An Order in Council to that effect was passed and inquiry for a suitable engineer was begun. Mr. Cooper at once protested vigorously against the proposal. The appointment by the Government of an independent engineer would, he said, place him in a position which he could not accept, that of a subordinate. The Phœnix Bridge Company warmly supported him—"It would be disastrous to have the proposed appointment finally made," wrote Mr. Deans, its chief engineer—and the Quebec Bridge Company was fully sympathetic. An interview followed with the Government officials at Ottawa, with the result that the proposed appointment was cancelled. As an outcome of this incident Mr. Cooper's authority was considerably increased. In effect he was thereafter given virtually a free hand to deal as he thought fit with the plans and specifications. The Phœnix Bridge Company thenceforward considered his pronouncements final and not liable to alteration either by the Quebec Bridge Company or the Government, and even the Department of Railways and Canals, in which the proposal for the new appointment had originated, accepted his signature as a final warrant of the sufficiency of the plans. It is certainly curious to find all these facts detailed in a report which describes Mr. Cooper as a man who "avoided the assumption of authority whenever possible." They seem to us to be consistent with the opposite view, namely, that he was a man who, ambitious of crowning a distinguished career with the credit of a great work, sought to concentrate in his own hands the dominant share of responsibility for its execution. Of any motive other than ambition he may be fully acquitted. The Royal Commissioners recorded their belief that Mr. Cooper was uninfluenced by contending parties and that he made his decisions and gave his opinions with absolute honesty. Not the slightest ground for disputing that belief can be discovered.

It is necessary to recall these personal details from the oblivion into which the passage of a third of a century has allowed them to fall. The sequel will show that they had a very material influence on the course of the drama which reached its last disastrous act on the afternoon of August 29th, 1907. Too late to save the bridge, but not too late to save the men working on it, Mr. Hoare hesitated to take independent action. Accepting the opinion of certain of his subordinates that there was no real danger—actually the chords were visibly bending beneath their feet—he decided to report the disquieting symptoms to Mr. Cooper at New York, and while awaiting his instructions to allow erection to proceed. Mr. Cooper, on the strength of such facts as had been reported to him, wisely decided that until all the circumstances had been duly considered no more weight should be added to the bridge. Unwisely, however, instead of sending his instructions to that effect to Mr. Hoare at the site, he telegraphed them to Phœnixville. Mr. Deans and his colleagues leisurely discussed the situation and decided to postpone action until the next morning. Almost at the minute at which that decision was made the bridge fell.

(To be continued)

Underground Railways at Chicago, U.S.A.

No. I

TO the list of cities having underground railways—or subways, as they are commonly known in the United States—for local rapid-transit service will soon be added the city of Chicago, U.S.A., which is now completing its first 8·75 miles of a deep-level tunnel system planned to have eventually a length of nearly 50 miles. The completed section, however, is not yet in operation. This subway is not for an independent railway system, additional to the other means of local transportation, but is primarily to supplement the existing elevated electric railways. A secondary purpose of the complete scheme, but one which is not fulfilled by this first section of the subway system, is to carry some of the coaches of the surface lines or tramways underground through the business district. Ultimately, the subways will permit removal of the "loop" terminal of the elevated railways which surrounds the centre of the business district of the city, the trains being then carried underground through this district. The main object of the scheme is to improve the speed and convenience of service and to reduce the present congestion and delay of street traffic within the business district. A list of cities having underground railways is given in Table I.

Local transportation by street railways

or tramways in Chicago has gone through typical stages of development, from horse and cable traction to the electric trolley wire system, supplemented in recent years by motor coaches, or omnibuses, a small proportion of which are on the trackless trolley system. Within its area of 200 square miles the city has a population of 3,400,000, while 145 square miles of tributary suburban towns aggregate an additional 1,300,000. For local transportation and rapid transit facilities there are 520 miles of electric street railways with overhead trolley wires, and 82 miles of electric third-rail elevated railways, while motor coaches serve some 225 miles of street. The three systems supplement each other and also overlap to some extent.

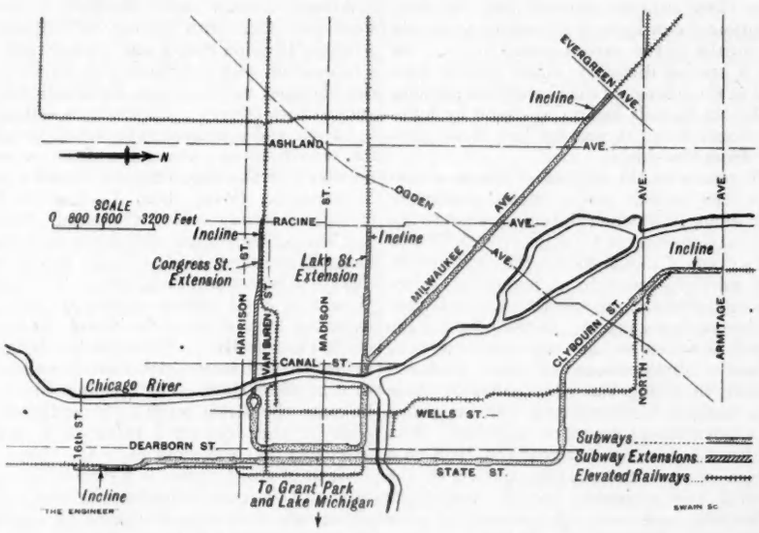

FIG. 1—PLAN OF CENTRAL PART OF CHICAGO

The many original independent street railway concerns are now combined under one company for unit management and operation, although some of the old companies retain a separate corporate existence. A similar situation applies to the elevated lines. However, negotiation and legislation are in process for a consolidated system under one company for unit operation of both the street railways and elevated lines, and possibly the motor coach lines. Of 930 million passengers carried in 1937, the street railways (Chicago Surface Lines Company) carried 77·7 per cent., the elevated railways (Chicago Rapid Transit Company) 16·1 per cent., and the motor coach lines (Chicago Motor Coach Company) 6·2 per cent.

TABLE I.—*Underground Railways*
(NOTE.—Not including tramway subways)

City.	Year opened.	Route miles.
London	1863	79
Glasgow	1886	16
Budapest	1896	2½
Boston	1898	23
Paris	1900	70
Berlin	1902	39
New York	1904	133
Philadelphia	1908	10½
Madrid	1919	2½
Barcelona	1920	4
Tokio	1927	5
Buenos Aires	1928	10
Sydney	1932	3
Osaka	1933	2½
Moscow	1935	18
Chicago	1941	10

Development of the local transportation system began with the first horse coach line, on State Street, in 1859, and other lines extended rapidly after 1870. Cable traction began in 1880, also on State Street, but horse-drawn coaches were practically obsolete by 1895, and cable cars by 1905. Electric traction began in 1890, and now covers some 520 miles of streets. The first elevated railway—the South Side Line—was put in operation in 1892, and the present system, with its main lines and branches, aggregates 82 route miles. Motor coach or omnibus service began about 1920, and is now operated both by the street railway company and the motor coach company; 200 miles of streets by gasoline—petrol—omnibuses, and 25 miles by trackless trolleybuses.

Suburban service, both steam and electric, is operated on several of the main line steam railways that enter Chicago, but this service mainly lands passengers outside the business district, so that many passengers then use the tramcars or the elevated trains to reach their destinations. However, it has been suggested that this service might be operated in co-operation with the combined local transportation or rapid transit service by means of a transfer ticket system, thereby permitting the incoming suburban passenger to leave the train at a station convenient to a surface or elevated line and continue his journey to a point conveniently near his destination, without payment of an additional fare.

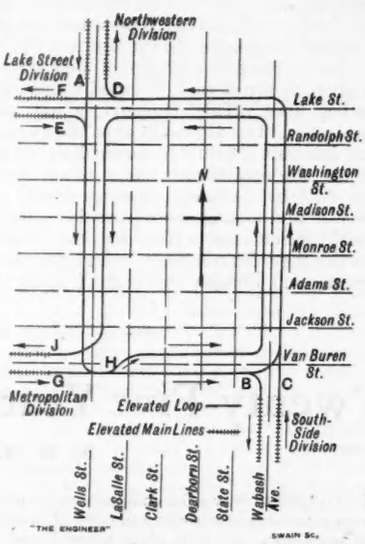

FIG. 2—PLAN OF THE "LOOP"

The elevated railway system, begun in 1892, largely as a means of providing a faster service between the business district and outlying areas than could be provided by the street car lines, was constructed by different companies. One of these constructed a loop line around a portion of the business district, thus enabling all the lines to reach the heart of the city. Steam traction was used at first, with small tank locomotives, but soon gave place to electric traction on the third-rail system, with train equipment of the multiple-unit type. The former separate companies are now consolidated in the Chicago Rapid Transit Company, and all the lines are operated as a unit system.

While a small number of the elevated railway trains use three terminal stations outside the "loop," most of them traverse the rectangular double-line loop. The operation of this loop line is peculiar, in that all trains, on both tracks, travel in the same direction. Trains of the North-West Division, the South-Side Division and the Lake Street (West Side) Division, all use the outside track. Trains of the Metropolitan (West Side) Division, which are more numerous on account of the number of branch lines, use the inside track. The operating arrangement may be explained with the aid of the diagram in Fig. 2.

FIG. 3—ARCHED ROOF TUNNEL

In this diagram the train movements are as follow:—Trains from the North-Western Division enter the loop at A, pass along its west and south sides and leave at B to continue their journey over the South-Side Division. Trains from the South-Side Division enter at C, pass along the east and north sides and leave at D to continue their journey over the North-Western Division. Trains from the Lake Street (West Side) Division enter at E, pass around the four sides of the loop and return to their own line at F. It will be seen that all these trains travel on the outside track. Trains from the Metropolitan (West Side) Division enter the loop at G, cross to the inside track at H and then pass entirely around the loop, leaving it again at J, where they have to cross the outer track to return to their own line.

Projects for underground railways in Chicago have been put forward during the past fifty years, some initiated by the city's engineers and others by private interests. Practically all of these schemes have been based upon two local conditions: first, the desirability of relieving the intolerable and increasing—and still existing—traffic congestion in the central part of the city; secondly, the desirability of providing more

rapid communication with outlying sections of the city.

Apart from the transfer of the elevated trains to subways, both the above conditions would be met by subways planned to carry some of the surface line cars through the congested districts, thus facilitating traffic by removing the cars from the streets, while also enabling them to traverse the district much more rapidly. A third, but somewhat remote, purpose in the more recent projects is the ultimate removal of the elevated loop, the value of which from a transportation point of view is offset by the noise of operation and the inevitable dirtiness and darkening of the streets occupied by the structure. In outside sections the elevated lines are built largely in the alleys which alternate with the main streets.

Linking up the elevated railways and providing for through trains, instead of each line using the loop as a terminal, was an obvious possibility, although with the lines in the hands of different companies there would have been difficulties in negotiating the use of each other's properties. With the

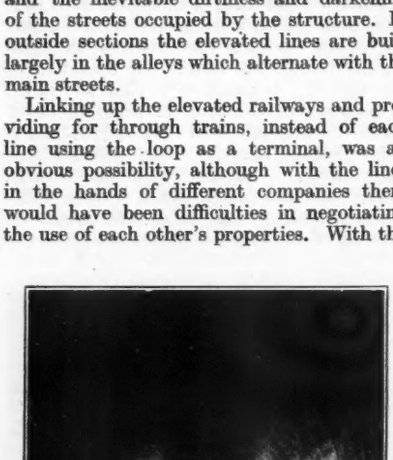

FIG. 4—CIRCULAR TUBE

advent of unit operation, as noted above, these difficulties have been removed. A project put forward as long ago as 1909 by the late Mr. John Ericson, then city engineer, provided for a north-and-south subway connecting with elevated railways at each end, and a loop subway by which street cars from the western part of the city would pass around the business district and return to their several routes.

These various subway schemes have been of two distinct types: deep-level tunnel lines and shallow lines for cut-and-cover construction in which the roof would be formed by the street surface. For lines of the latter type various supplementary features proposed in different schemes have included travelling platforms, underground side walks, and shops and shop windows and entrances at basement levels.

The adopted system is of the first type, having its rail level 44ft. to 48ft. below the street surface. One reason for this was the vast network of public utilities near the surface, and another was the minimising of interference with street traffic during the period of construction. Twin arched roof single-track tunnels are used for the greater part of the work, but there are also more than two miles of twin single-track steel-lined circular tubes. In Fig. 3 is an interior view of one of the single-track arched roof twin tunnels; and Fig. 4 is a similar view in a circular tube, but before the placing of the concrete lining.

It may be noted that Chicago has had for some years a rectangular network of 65 miles of small tunnels of horseshoe section, 6ft. by 7ft., having a single track of 2ft. gauge and operated by electric locomotives. This system, which is exclusively for freight traffic, has its rail level about 45ft. below the streets. At a few points the new and larger tunnels of the passenger subways intersect or embrace these older tunnels, necessitating the construction of new links or diversions to restore the breaks in the narrow-gauge lines. This was a special difficulty where shields were used in tunnelling, as the abandoned portions of the old tunnels had to be closed by bulkheads and filling to prevent loss of air pressure from the shield.

To return to the subject of the new subways, the present project dates practically from June, 1937, when the city applied to the Federal Government for a loan of £6,875,000 and a grant of £5,625,000 for the construction of a subway system to accommodate street cars and elevated railway trains, as planned by the city's engineers. In these figures the pound is taken as the equivalent of four dollars. Modifications of this proposed system, including the elimination of those lines intended for street cars, were suggested by a Government board of engineers. As a result an agreement was made in 1938 on a system to cost £10,000,000, for which the Federal Government would contribute £4,500,000 and the city would provide £5,500,000. With further modifications in 1939 and 1940 the Government grant was increased to £5,782,500, and the total estimated cost to £11,500,000. In addition to the construction of the subways, the city will pay for the steel inclines or viaducts connecting with the elevated railway lines, and also for the escalators, ventilating fans, station plumbing and interior finish, and electric light and power facilities, except those for traction purposes.

Operation of the subways is proposed to be put into the hands of an operating company, which will include representatives of the present companies and the city, and which will operate the entire system of local transportation by street cars, elevated trains and omnibus lines. This company is not yet organised and there is doubt as to the merger of all interests concerned, particularly as to whether the omnibus or motor coach company will be included. The problems of franchise and finance are also under controversial consideration. However, the scheme provides that this company, or an equivalent concern, will assume the cost of track or permanent way, automatic block signals, interlocking plants, and power distribution for electric traction and communications. War conditions hamper the purchase of the necessary rolling stock, owing to priority rules on steel for defence works and equipment.

The two main routes included in the present or initial subway system are as follows, and are indicated on the map, Fig. 1. First, from a connection with the North-Side Division of the elevated railway near Armitage Avenue and Sheffield Avenue south-east and south by way of Clybourne Avenue, Division Street and State Street to a connection with the South-Side Division of the elevated railway near Sixteenth Street and Wabash Avenue. This route is 4·9 miles in length, and is estimated to cost £7,500,000 for. construction. Secondly, from a connection with the Logan Square branch of the Metropolitan (West Side) Division of the elevated railway near Evergreen Avenue and Milwaukee Avenue, south-east and south along Milwaukee Avenue, Lake Street and Dearborn Street and then west in Van Buren Street to a single-line terminal loop or reversing loop at Franklin Street, just east of the Chicago River. This line is 3·85 miles in length and its construction is estimated to cost £6,580,000. The terminal loop will be near the street surface, in order to be clear of the deep-level tubes of a future extension that will cross under the river.

Each of these routes is a double-line subway with twin single-line tunnels, and having either island or side platforms at stations. In the congested business district, with its concentrated traffic, the two parallel subways on State Street and Dearborn Street will have continuous platforms for a length of 3500ft., connected by transverse transfer tunnels to facilitate exchange of traffic between trains of the various routings. The parallel stations will also be connected above the tunnels. There will be three inclines or steel viaducts connecting with different lines of the elevated railway system.

Two extensions of subway route No. 2 are authorised, as shown on the map. First, westward from Wells Street and under Congress Street to a connection with the main line of the Metropolitan (West Side) Division of the elevated railways near Racine Street. Secondly, westward in Lake Street from Canal Street to Racine Street, to connect with the Lake Street (West Side) Division of the elevated railways. With these two extensions built, it would be practicable to abandon these two elevated lines east from Racine Street and to dismantle the north and east sides of the elevated railway loop.

(To be continued)

Twenty-Five Years of Marine Progress*

By W. A. WOODESON

I PROPOSE to draw a few comparisons between conditions existing to-day and those of twenty-five years ago. There is often a great deal to learn by putting side by side corresponding pictures of to-day and those of preceding periods. A great deal can be learned by comparison, and I have been tempted to span twenty-five years because it takes us back from the stirring times we are now experiencing to similar experiences we faced during the 1914–18 conflict.

COMPLEMENTARY INDUSTRIES: SHIPPING AND SHIPBUILDING

The figures which were published in 1916 of shipping losses during 1915 were considered very serious indeed at the time, but appear light to-day. Our losses in 1916 were less than one half of those in 1940, and from figures available the losses in tonnage during 1940 were more than double that of the new tonnage launched during the same period from British shipyards. In considering any figures appertaining to shipbuilding, it must be borne in mind that the output of tonnage in Britain prior to the 1914 war had for quite a period been equal to about 60 per cent. of the world output. Prior to this war our output varied to round about 35 per cent. of the world output.

The part played by American shipyards in the early years of the last war represented less

* Presidential Address—North-East Coast Institution of Engineers and Shipbuilders.

than 1½ million tons per annum, but by the end of the 1914–18 war the rate of production was approximately 3 million tons per annum. To-day the United States are being called upon to extend their output again. This time more circumspection has attended the planning of the operation. We are looking forward to a more economic product in time to be of vital service in replacing lost tonnage. We must all realise that shipping losses have been very great. These losses, however, we hope will soon be replaced, and we must advocate the construction of shipping both in America and this country to the greatest possible extent. We must not, however, forget our experience when "Cease fire" took place at the end of the last war. We had an enormous amount of shipping, and if the same conditions prevail again at the end of the present war it will be most essential that the Government should act in some very forcible and drastic manner to prevent the post-war tragedy experienced on the previous occasion.

One of our responsible engineering journals in 1916 told us that when the war ceased the Allies were pledged to enormous trade paths which would be open to us, necessitating the full use of all new machinery, all the new factories and all the ships we were building, and expected to build, to enable us to hold the markets which would be open to us. I trust that we may profit by such wrong and misleading statements. That we are likely to do so may be seen from a warning very wisely given in a paper to the Institution of Naval Architects by Sir Archibald Hurd last year. He warned us that unless our shipping losses were going to increase instead of, as we anticipate, be reduced, the shipping on the Register of the United Kingdom will be considerably greater than it was at the beginning of the war. The Ministry of Shipping therefore will have no mean fleet of new cargo ships in its possession, and however wisely the war plans may be laid, and however expeditiously they may be carried out, unless the Admiralty and the Ministry of Shipping act drastically and rapidly the industry will probably face another post-war crisis.

Sir Archibald Hurd also points out that the arrears in liner construction which were heavy before the war will have increased, and the shipping companies, confronted with more intense and more uneconomic competition than in the past, will not be in a position to place contracts. Shipping having been controlled from the beginning of the war, owners have had no opportunity to create large reserves on which to draw for replacement purposes. Therefore, under such circumstances a post-war slump in merchant shipping is almost inevitable, unless strong precautionary measures are adopted. No one can foresee the post-war policy of the Government or of the Ministry of Shipping, but at the end of the last war orders were cancelled and work in the various yards ceased wherever possible. I consider that in making such statements as these, Sir Archibald Hurd has given us a warning well worth listening to, and certainly worthy of the greatest possible consideration by those in high authority.

Comparisons of the years 1916 to 1941 would not be complete without a reference to the successful attempt at rationalisation made in the past fourteen to eighteen years. Between 1916 and 1920 there was a considerable increase in the number of yards in commission, to counter the requirements of war, but by 1938, largely due to the activities of the National Shipbuilders Security, Ltd., made necessary by the recurring slumps, the number of shipbuilding yards had been considerably reduced.

These facts are interesting, particularly when they are considered in conjunction with the present shortage of tonnage and the scramble on both sides of the Atlantic to get new yards into production. Perhaps the experience we have had, and are having, will be sufficient to keep awake the policy I have advocated for many years, and will increase the realisation that this country's very life depends upon ships. Necessary encouragement must be forthcoming from the Government and other authorities to ensure a state of adequate production and employment of new tonnage in the future. At the beginning of the war the British Shipping (Assistance) Bill, 1939, which had passed its second reading, was abandoned. It proposed by loans, grants, and subsidies to stabilise the two complementary industries of shipping and shipbuilding. These industries are now rigidly controlled and a crucial situation will no doubt arise with peace.

It would be both dangerous and perhaps foolish to attempt to prophesy about the way things will turn, but one thing we must insist upon—that there shall be no recurrence of the unhappy years between the two periods we are considering to-night.

Design and Building Technique

While I have no intention of expressing any opinion on ship design, yet to make this survey comprehensive, I would like to ask if any conclusions can be drawn from comparison between the ships of the last war and those of this war. Modifications in design in hull form which have taken place during the last twenty-five years are not revolutionary, and they are not immediately obvious. Great benefit has no doubt been derived from the experience of these years, and particularly from wider use of the experiment model tank.

Modifications have been multiplied during the last twenty-five years to improve the efficiency of rudders and streamlining of stern posts, &c., and considerable progress has been made in propeller design. The question of cavitation of propellers is a scientific problem which recent years has shown to be more related to design than material.

The intervening years have shown that more modified types of cargo ships for specific purposes, with an increasing speed and tonnage, are gradually replacing the cheaper general vessel. Due to the primary requirements of the Admiralty, the urgency of speed of production and shortage of material and skilled labour, the natural evolution of ship design was rudely interrupted in 1916. Expediency produced the loosely termed "standard ship" of which perhaps the "concrete ship" was the most remarkable and lamentable example. There were some who felt that the advent of the "standard ship" was a move in the right direction. It was appreciated by all that the variety of duties was too great for complete standardisation, and the development of as much uniformity within the limits of a minimum number of types was felt to be beneficial. The building programme in the United States will, we hope, demonstrate such a modified standardisation. It foreshadows a distinct improvement on the performance there during the last war, and the series of types covering cargo and passenger-cargo ships represents reasonable balance of the varying factors.

Passenger Liners

The course of progress can be partially gauged by considering the history of the larger passenger liners. During the years between the two wars, mention must be made of the prolonged triumph and ultimate passing of that fine Tyne-built ship, the "Mauretania." In 1916 she was already a veteran in service and in achievement, and had even then held the Blue Riband for a decade. She was, however, destined to carry this high honour for a decade longer, and not until 1928 was she out-paced—by the "Bremen."

In 1916 the "Mauretania" was capable of an Atlantic crossing at an average speed of 26 knots; to-day the "Queen Mary," and no doubt her sister ship, the "Queen Elizabeth," are capable of a prolonged average of over 30 knots. These latter named vessels, large and fast as they are, are not entirely representative of the present-day passenger liner, which at the outbreak of war was showing a tendency in design to provide greater comfort than large, high-speed vessels. The "Queen Mary" and her sister ship, however, were the answer of Britain to the challenges of the German, French, and Italian competition for predominance in the North Atlantic, and for that intangible commodity—Prestige.

In considering the passenger liner, we must not overlook the attempt of the shipping companies during their lean years to capitalise the tourist proclivities of the nation. This led to the embellishments which produced that awful creation "the floating hotel." Much less progress of a fundamental kind has been noticeable, and the main problem of sea-going comfort, the reduction of rolling and pitching still persists. These two unpleasant evils exist in spite of the many experiments which have been made. Perhaps the most venturesome experiment was the development of the gyroscope. There have been many experiments with this apparatus, but the factors of expense, space, consumption of power, and unreliability still counteract the undoubted advantage in stability.

Welding

Modifications to the technique of shipbuilding and allied industries which have taken place in the last twenty-five years are eclipsed by the attention that has been, and is being, given to the use of welding. This development is fundamental in that it affects, or should affect, the design of the product. Riveting is still the major means of construction in this country, but gradually the saving in weight and material, due to welding, is becoming more recognised for all constructional purposes. The survey of the effect of welding on the fighting qualities of ships will be one of the most interesting post-war considerations of naval architects, especially in view of the mixed performance of the German capital ships, whose construction so largely depended on electric arc welding.

A certain American shipbuilding concern has laid down a yard and shops expressly equipped to produce nothing but all-welded vessels. This company, I believe, has something like twenty-six merchant vessels of an important type on order. They are ships of considerable size and capacity. The same yard in June of this year launched an all-welded steamship. This vessel has a displacement of 17,000 tons, and is claimed to be the first all-welded passenger ship built in the world. I understand that two sister ships should now be in the water.

I think due note should be taken of this considerable development, because a great deal has been said and written on the technicalities for and against this method of construction. Here in 1941 we have an experiment on a most lavish scale. The results obtained by the American vessels should shorten discussions as to the part that welding can play in shipbuilding in the future.

Propulsion

Diesel. — One of the most interesting features characterising the period between the two wars has been the parallel development of diesel and steam propulsion. The advance of the diesel engine coincided with the growth of shipbuilding activities abroad. For the first time this country could not consider herself the unrivalled leader of design and practice. Diesel engine manufacturers in the Scandinavian countries and on the Continent for a while were in advance of our activities here. Fortunately, this situation is becoming regulated to better proportions. The diesel ship was largely an experiment in 1916. To-day a very impressive proportion of new tonnage is driven by the internal combustion engine.

One of the outstanding changes in the period under review has been the general adoption during recent years of the two-stroke engine in place of the four-stroke. Modifications in designs and other improvements have reduced the fuel consumption in diesel vessels by more than one half what it was in 1916. A great advance also lies in the reduction of maintenance costs and the attainment of a high level of trouble-free performance.

The Turbine.—Steam has, however, made commensurate progress. These twenty-five years have seen the full reaping of the benefits of the steam turbine. Thus, to take the North Atlantic as a basis of comparison, we speak to-day of vessels being driven by turbines developing over 150,000 S.H.P. in some of our great liners. At the same time we remember that 70,000 S.H.P. of the "Lusitania" and "Mauretania" which represented the peak of progress in 1916.

An excellent comparison is also obtained in the realisation that whereas in 1916 1·4 lb.

of coal per S.H.P. was considered good consumption, to-day a high-class turbined ship only requires between 0·6 lb. and 0·8 lb. of coal per S.H.P.-hour.

The years from 1916 onward witnessed the overcoming of many of the outstanding difficulties in the path of the successful operation of the geared turbine. Gearing faults during 1920 and 1930 were tackled on a rational basis and are now nearly eliminated. There has been a great deal of experimenting in connection with this transmission of power from the main engines to the propeller shaft. Much of the progress recently made in propulsion is related to this modification. The wider adoption of indirect drive in diesel ships may lead to some interesting development in the future on the same lines, particularly in view of the contemporary work that is being done in conjunction with high-speed oil engines.

Reciprocating Engines.—The faithful servant of steam, the reciprocating engine, has not been allowed to slip into disuse or oblivion. Throughout the history of this Institution our members have played a valuable part in the gradual improvement of the reciprocating engine. To-day it still holds an important place amongst the prime movers of ships.

The combined reciprocating engine and turbine has also demanded some attention. An interesting possibility was indicated by Dr. A. L. Mellanby in his Thomas Lowe Gray Lecture, entitled "Fifty Years of Marine Engineering," to the Institution of Mechanical Engineers, in which he stated that there were possibilities for the combined high-speed reciprocating engine and the exhaust turbine, both driven through gearing to the propeller shaft.

Summary.—The chief factors which have emerged from twenty-five years' struggle between the conflicting interests of the various types of propelling systems are the thermodynamic economy of the oil engine, the fuel versatility of the turbine, and the low capital cost of the reciprocating engine. These factors must still be balanced, dependent on specific and peculiar circumstances surrounding each case. I consider it fortunate that no system has had a preponderant advantage. Competition has been healthy in that it has not killed or wiped out any of the competitors, but has given all a new lease of life.

Coal and Oil

In 1916 it was becoming obvious that acute rivalry would soon develop between coal and heavy petroleum as the prime source of energy for ship propulsion. It will be seen from the figures given of world tonnage in Lloyd's Register that the proportion of tonnage using oil has increased from 4 per cent. to that of 54 per cent. between 1915 and 1940. Internal combustion driven vessels have increased from 234,287 tons to 16,700,000 tons, whereas steam-driven ships burning oil as fuel have increased from 1,310,000 tons to 20,600,000 tons. This makes a total increase of tonnage using oil from 1,545,000 tons to 37,300,000 tons. During the same period the total tonnage using coal has been reduced from 44,000,000 tons to 31,000,000 tons.

Another very significant feature is that the tonnage of tankers on the Register has increased from 1½ million tons in 1914–15 to 11½ million tons in 1939–40. Stabilisation of the relative positions of coal and petroleum has been partially effected. The foreign fuel is in the ascendency just now, but I would like to express the opinion that the present position is only a temporary phase.

Considerable disappointment has ensued from the efforts to meet the challenge of petroleum oils with pulverised coal, the liquid products of low temperature carbonisation and hydrogenation. The commercial difficulties have greatly obstructed the progress of this important method of utilising coal. It is true that the ash problem still persists to the detriment of the coal-fired, internal combustion engine, but the difficulty is not insurmountable. Pulverised fuel has demonstrated its great suitability in power stations, and other important steam generating schemes on land, and it has also been successfully used at sea.

Should the time arrive when high capital expenses can be overcome, we shall hear more of the hydrogenation of coal.

There is no doubt that under existing circumstances highly powered vessels on regular routes with uniform bunkering facilities should be fuelled with oil. At many points, however, on the world's seaboard, and particularly on our own coasts, the immediately accessible fuel is coal. The greater proportion of the world's tonnage would benefit from the ability to bunker either oil or coal at will. I believe this plain fact which received considerable attention some years ago will again emerge into importance and pulverised coal will find its place as an alternative fuel with oil in dual-purpose burners.

Water-tube Boilers

The water-tube boiler has played a most important part and is closely associated with the progress which has been made to the extension of the various methods of raising steam. Steam temperatures and pressures have been more than doubled in the last twenty-five years for marine purposes, and pressures have been fairly common at 500 lb. per square inch and temperatures at 800 deg. Fah.

During the period under review, the size of individual boiler units has also increased with a corresponding reduction in the number of boilers. This has been marvellously illustrated in some of the latest designs of steam generating sets for H.M. ships.

Not a little of the success which has been attained by large units working under high pressures has been the solution of the problem of condenser tube corrosion, thus enabling a closed water system to dispel the old bogey of concentration and scaling.

There have been numerous designs of water-tube boilers, several of which have been tried with more or less success, *e.g.*, the Benson, the Loeffler, the Velox, the La Mont, &c., all of which have attracted some attention. There has also been some work done with the mercury vapour boiler. The most extensive progress, however, has been made with the plain, well-designed, three-drum boiler, which perhaps has shown more usefulness than other types, especially where a very large capacity of steam generated has been required from a small space and a small weight. One or two types of two-drum boilers have also been developed which can claim similar advantages.

Mechanical stoking of ships' boilers has met with limited success since the last war. The undoubted gain, however, of efficiency over hand firing has been clearly demonstrated in several cases, especially in several C.P.R. ships and Irish Coast ships of the L.M.S. Company. There seems little doubt that steady progress must continue in these fields where coal is the undisputed fuel.

Secondard Equipment

In the last twenty-five years the use of electricity on shipboard has made considerable progress. Electric motive power has been used as main propelling machinery, but the real progress, up to now, applies particularly to auxiliary machinery. Electricity for auxiliary purposes was really introduced towards the end of the last century, but the experimental stage was so prolonged that by 1916 the progress was rather disappointing. The early performances in connection with this type of power were somewhat uncertain, and therefore mitigated against its obvious advantages. This uncertainty has largely been removed in the intervening period. We have to thank enterprising owners who have faced the risks of departure from established practice, and without whose co-operation progress cannot be made.

An outstanding development in connection with electrical power on ships has been in the electrification of various types of deck machinery. In 1916 most of this class of machinery proved to be expensive and uncertain. To-day, however, the same machinery still has a higher first cost than steam, but by virtue of its reliability in performance it has proved to be much less expensive than previously. These remarks especially apply to the electric winch which is now not only extremely reliable, but has been sufficiently reduced in cost of maintenance and upkeep as compared with the original electric winches to induce owners of certain classes of ships to recognise the advantages of applying electric power to this class of deck machinery. This does not mean that the electric winch has supplanted, or will necessarily supplant, the steam winch. Both have their rightful field of application.

Speaking about subsidiary machinery generally, the American Society of Naval Architects and Marine Engineers is of the opinion that modifications now going on in types, and designs are all for the good and benefit of shipping.

Electrical deck machinery, materials used in the construction of deck machinery, welded construction and cast steel largely supplanting cast iron and semi-steel, the application of ball and roller bearings, particularly for electric motors and steering gear control, have all greatly helped to improve performance in every way. Every attempt is also being made to retain the desired ruggedness and reliability of this class of equipment. At the same time the commercial aspect is receiving every possible consideration and no attempt has been made or is likely to be made to introduce improvements not fully warranted by the many factors that influence the design, including cost.

Safety at Sea

Great attention has been paid since 1916 to the means for increasing the safety of life at sea. It is true that the hazards of war place the problem for the time being in quite another category, but in contrasting 1941 with 1916 there remain a number of points worthy of mention. The precautions taken to avoid fire have made a marked advance; the safeguard of watertight divisions has been largely explored, and the provision of hatch covers, of improved design, and materials has been effected.

It is true that nothing in the period under review approaches in importance the previous introduction of wireless telegraphy, but the changes mentioned play their part in reducing the normal peacetime risks of what still must be considered one of the perilous avocations of man.

Research and Materials

It was felt in the early days of the last war that industry had much to learn from the research contributions of other countries. Subsequent experience, however, enables us to look at the subject of research as related to the size or dimensions of a business. It was realised that the small firm cannot afford research, except in the direct solution of its manufacturing problems. It was felt that only large organisations were able to carry the financial charges of expensive and scientific investigation which could foster pure research. We should like to ask the question, Does this mean that to obtain the undeniable benefits of scientific research we must possess a big business?

For some time now successful corporate efforts have produced a number of useful results by central research, and an extension of this system must give beneficial results, both in an individual and corporate respect.

Nobody can deny that great industrial progress has been made, say, since early 1938, due to the preparations for war. This inevitably causes the question to emerge, Why does this scientific progress make such rapid strides during a war? Also another question, Is war essential to such progress? My answer, of course, is in the negative, but it is a matter that deserves thought and discussion.

The extraordinary and rapid scientific progress which is also made during a war to acquire expert knowledge necessary to perfect the means to destroy life and property, and not likely to be of much commercial benefit after a war, should also demand a discussion amongst scientists themselves. It was very pleasing to note at the recent meeting of the British Association held in London that comments from several eminent scientists foreboded such discussions with a view to forcing the principle that science is intended to assist in the preservation of humanity and not in its destruction.

The intervening years of research have no

doubt given us greater knowledge, not only of the materials that we handle, but what is even more important, of the precise requirements in materials. This has had the beneficial effect of allowing both cheaper material to be used satisfactorily and of encouraging the development of new materials.

A great deal of work has been done in the production of non-ferrous alloys to meet the effects of corrosion, of sea atmospheres, high temperatures, and strenuous duties. The part played by nickel in this respect has also been considerable. Good progress has also been made in the development of aluminium-bronze, whose mechanical properties and resistances to wear and corrosion we know to be promising if the difficulties of founding could be overcome.

In considering the new materials that have developed between 1916 and 1941 perhaps no example is so illuminating as that of the progress made in the use of stainless steel. Its interest is partly associated with the fascinating problem of corrosion. The rusting of iron and steel has always been a major problem to engineers. Much has been done to develop protective coatings, paints, plating, metal spraying, &c., but it has always been felt that the real solution would not come until a modification in the structure of the metal to resist oxidation was available.

Stainless steel, no doubt, deals with corrosion most successfully, but, unfortunately, it bears the disadvantage of the excessive cost of its alloy additions. There is no doubt that the advance in the development and improvement, and consequently the utility of stainless steel, has been very great since 1916, and its application for both shore and sea purposes has greatly expanded. The expense of this material may seem to preclude its application on a very wide scale, and it is here where scientific research can be of immense value. I believe the use of this material has been so extended that an all-stainless-steel lifeboat has been produced. It is already possible to roll this material into large plates, and as its performance has been so well demonstrated, there seem only the economic limitations to wider developments.

Considerable attention has been given to the developments in the use of aluminium and the light alloy between this war and the last. By virtue of this development, these metals have become very valuable to us and their control is rigid. When the difficulties of supply ease with the conclusion of the war, we can anticipate a considerable extension in their use in ship construction. The great and almost wonderful improvements in the manipulation of this material since 1916 have made it almost invaluable to us in the production of aircraft.

A more easily worked constructional material in this connection might be developed by taking advantage of the rapid facilities offered by synthetic plastics. This term is wide in its scope, but usually refers to an ever-increasing number of synthetic organic products. There are three principal classes of this material, *i.e.*, the resin base, celluloid base, and the protein base. They have been developed to a fairly high degree of physical performance. Mechanical strength and optical properties and resistance to corrosion are well developed, but at the present time one flaw is their low resistance to the effect of heat. There seems, however, little doubt that plastics, if they have not already done so, will find a place as structural material for aircraft and other manufactures of various types.

Conclusion

The past twenty-five years have shown a widening in the interests of the Institution, as evidenced by the range of subjects discussed here. The majority of our papers have been on a good practical and instructive basis, and perhaps we should continue on these lines. We might, perhaps, vary our style now and again and encourage discussions of such a nature as to make those responsible realise that it is absolutely necessary for legislation and its application to become a help and cease to be a hindrance to those manufactures so vital to the interests of the nation and upon which the nation so greatly depends.

Again, the relationship of employer and employee between 1916 and 1941 is of interest. The mentality on both sides has altered. During the 1914–18 war there were labour troubles due fundamentally to the absence of a feeling of mutual understanding, so necessary to ensure a vital interest in the struggle. To-day, however, excepting for a few minor cases there is unity of purpose and interest which has eliminated major labour difficulties. We are, however, as an Institution more concerned about our own contribution to the problems. Twenty-five years ago we were genuinely concerned about the reconciliation of capital and labour. Some progress was made, but the great trade slumps which occurred almost continuously from 1926 to the outbreak of the present war threw all discussions back into the melting pot.

These strange years with their bitter struggles and dangers must surely provide recompense, and a new opportunity for understanding is slowly and surely arriving, and has emerged from the danger of 1940. I sincerely trust that such a new understanding will bring about a feeling, which must and will free us from the idea that a constant opposition between employer and employed is inevitable.

This brief survey of the many and varied aspects of our interests must necessarily be incomplete, but I hope it will be acceptable.

I also trust the comparison of 1916 and 1941, desultory though it has been, will have provided a mental background with food for thought, without which we cannot hope to meet present difficulties or solve future problems.

American Engineering News

American Research in Steel Manufacture

A list of problems relative to the physical chemistry of steel manufacture has been prepared and circulated by the American Institute of Mining and Metallurgical Engineers through a special committee on the physical chemistry of steel making. The list was prepared after consultation with a number of metallurgists, and its purpose is to furnish research laboratories with problems whose solution would aid in developing a better understanding of the steel-making process. Many of the problems can be worked out in university or other research laboratories. Others may be attacked most successfully by co-operation of the research staff with the operating personnel, a co-operation which is highly desirable. There are four main divisions. First, specific heats, entropies, typical slags and refractories; free energies of oxides, sulphides, nitrides, &c.; heats of formation; equilibrium constants; effects of temperatures on reactions; determination of solubility curves; elimination of hydrogen in molten alloy for open-hearth steel. Secondly, other physio-chemical problems; reaction and diffusion rates; effect of temperature and agitation on reaction rates in the open-hearth furnace; fluidity and surface tension; allotropy in liquid iron; segregation in liquid steel; fluidity of cast steel. Thirdly, furnace design and operation; desulphurisation in the basic open-hearth process; nitrogen content during blow in the Bessemer process; effect of proportions of hot metal charge on ingot quality; mineralogical composition of slags during various stages of the heat. Fourthly, rapid methods for chemical analysis; micro-chemical methods; temperature measurements of bath, slag, and furnace bottom, &c.; measurements of viscosity, surface tension, and gas pressure in slag. Nearly 200 subjects or problems are listed, and investigators who are now working on any of them are requested to notify the committee, which is undertaking to act as a clearing house for information.

Submerged Breakwaters

For reducing wave action at beaches and so preventing shore or beach erosion, the submerged breakwater is a type of structure that has proved effective, while it has not the disadvantage of unsightly appearance of an ordinary breakwater or a series of jetties, which latter also interfere with free usage of the beach. One of the most extensive applications of this means of beach protection is at Chicago, U.S.A., where storm waves with an open sweep of 80 to 100 miles devastated the lake front, and unsightly jetties of pile and rock construction proved ineffective protection. Special studies to determine the effect of submerged breakwaters upon wave action have been made in the wave tank of the United States Beach Erosion Board, using model breakwaters of vertical, triangular, and trapezoidal section. Some general conclusions are as follow:—First, an underwater structure parallel with the shore will decrease height and force of waves, and also decrease the littoral drift, thus protecting the beach without disfiguring it. For harbour protection, no waves above a specified limit must reach the anchorage area. Secondly, a vertical wall, such as a line of steel sheet piling, suitably braced, is most effective; but a rock mound is almost equally efficient, so that choice would be governed by construction costs and local conditions. Thirdly, a low structure will reduce wave action under all conditions. The extent of this reduction can be controlled by the height of the structure. Fourthly, where protection from storm waves is desired, the structure should have a submergence of 1·2 or less. In 20ft. of water a 6ft. wave will be reduced to 3½ft. by vertical barriers, to 3¾ft. by a trapezoidal barrier, and to 4ft. by a triangular barrier. For a reduction in wave height of 33 per cent. in 15ft. of water, a vertical barrier need be only 12ft. high, while a trapezoidal barrier would require a height of 13ft. 4in. These studies are being continued.

PUBLIC WORKS PLANNING IN AMERICA*

During the past few weeks preliminaries have been cleared out of the way to permit the Public Work Reserve plan to begin functioning. Its sponsors, the Federal Works Agency and the National Resources Planning Board, have appointed regional directors and have conducted meetings in various cities to familiarise Federal officials with their necessary jobs of co-operation with local governments. Manning of the regional offices is now under way, and before long representatives will begin calling on State, city and county officials.

It is important that the P.W.R. and its function be understood, for its purpose is laudable, and its present objective, if we understand it correctly, is compelling. As to purpose, P.W.R. was set up to sell the advantages of long-range public works planning to local governments; the model is a six-year programme as developed by the Resources Board for the Federal Government, a programme that is to be revised annually as projects are taken from the list for actual construction. The objective is to get a broad programme of public works outlined now so that construction from it can be used to cushion the shock that reduction of defence spending will cause. As an advocate of businesslike municipal housekeeping and of insurance against a rainy day, the Public Work Reserve is a constructive development. Local government officials have much to gain, both for their communities and for the nation at large, by giving prompt co-operation to the P.W.R. effort.

The immediate task of P.W.R. is to accumulate a listing of needed public improvements. In this respect the task is somewhat reminiscent of the early days of P.W.A., although the objective is an orderly, well-thought-out programme rather than a mere inventory; it is furthermore necessary that local projects be selected realistically as regards local financing, for no promise of Federal aid is involved. With the programmes outlined, P.W.R. then envisions surveys, investigations and design of the most urgent and useful projects so that they will be ready for a quick start on a construction programme when and if needed. Federal man power and money will be brought into this designing stage, according to the plan. In short, long-range planning of public works is needed now as never before, and the Federal Government is rightly taking the lead in fostering it.

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TRANSPORT IN POST-WAR PLANNING

IT is yet one more proof—if proof were needed—of the high morale of the people of this country and their belief in victory at a not too distant date, that so much thought is being given at the present time to the conditions that will exist when the war comes to an end. It is now some months since the Government, in recognition of the problems that would urgently need solution so soon as hostilities ceased, set up the Ministry of Works and Buildings, with Lord Reith as Minister, and appointed Mr. Greenwood Minister without Portfolio one of whose tasks is that of making preparation for the period of reconstruction. Since that time various bodies have started in one way or another to gather information or to get together organisations which can give the matter their attention in relation to the particular spheres of post-war operation that are of interest to them. Somewhat naturally, the Royal Institution of British Architects was one of the first in the field to study such matters. Its Reconstruction Committee recently issued its first report—a review of the present situation in regard to planning authorities which, particularly in its references to railways, roads, docks, canals, and public utilities, is not without interest to engineers. But other bodies are not far behind. In a Journal note in this issue we record the appointment by the Institution of Electrical Engineers of a Committee whose task it will be to study post-war problems in electrical engineering. It will, too, be known to many that the Institutions of Civil and Mechanical Engineers are also considering what they can undertake to do on similar lines, and that these three Institutions have agreed to set up a small Joint Committee to co-ordinate their activities. This kind of planning activity is not confined to this country. Elsewhere in this issue we reprint from our American contemporary *Engineering News-Record* a paragraph dealing with the Public Works Reserve plan, the objective of which is "to get a broad programme of public works outlined now so that construction from it can be used to cushion the shock that reduction of defence spending will cause." The latter part of that sentence well expresses one of the main aims of post-war planning. No one wishes to experience again the same kind of deep trade depression that followed closely upon the ending of the 1914–18 war.

One of the more important facets of post-war planning and one to which some attention is, no doubt, being directed now, is that concerned with transport. Everyone agrees that the existence of a healthy transport organisation is as important to a nation's well-being as the flow of blood through the human body. Yet the problems of the organisation of such a healthy transport system after the war, and the methods by which its various parts are to revert to individual instead of Government control, are likely to prove remarkably thorny to solve. That interest is already being taken in the matter is shown by the recent short debate in the House of Lords. Lord Monkswell, who was critical of the railways, and Lord Balfour of Burleigh, who held an opposite view, were both in agreement in desiring to know what, if any, plans the Government has regarding their post-war status. The road industry, to judge from Mr. Nicholl's Presidential Address to the Institute of Transport, is more particularly concerned at present to learn what action the Government intends to take regarding wartime road haulage rates, a matter that still remains in doubt, although the main lines of the wartime organisation of the industry have just been announced. Yet when Mr. Nicholl says, "Road transport remains to-day essentially an industry of small operators, but it is efficient in its operation and it possesses an elasticity and a power of quick adjustment to circumstance which might be found wanting in many more highly organised industries," he is referring to qualities that it is very desirable should be preserved in any post-war reorganisation. Canals have not so recently entered into the picture. But it may be assumed that, acting on the report of Mr. Frank Pick, the Government intends to develop them as much as possible for wartime purposes, with the consequence that they will deserve close consideration after the war. The development of civil air transport has been almost wholly checked in this country as a result of the war. But much of value will have been learnt from war experience that must be applied in the operation of civil air lines in the post-war era of reconstruction.

For the purpose of carrying on the war, the Government learnt by experience that it was necessary, at least for inland transport, to provide unified control, and Lord Leathers, the Minister of Wartime Transport, now controls the operation not only of the railways, the roads and the canals, but also that of docks and harbours. But what is to be the position after the war? The various forms of transport can hardly be permitted to fall back into that state of competition, somewhat relieved by Government regulation, which existed in 1939. The problem is rendered the more complicated by the differing structures of the transport systems, ranging from the railways organised into four large groups, to road haulage, operated by a multiplicity of individual small concerns. Moreover, though it is possible to make sweeping statements regarding the particular classes of goods the various types of transport are especially and individually adapted to carry, the fact remains that were competition allowed to act freely, it would have a ruinous effect upon all of them. Nationalisation, particularly of the railways, has been suggested as a solution. But we rather agree with Lord Balfour of Burleigh that nationalisation of the railways must logically be followed by nationalisation of other forms of transport, and we cannot believe that transport concerns would desire to see even the present degree of Government control perpetuated, far less the more complete control involved in nationalisation. In the debate in the House of Lords, Lord Leathers remarked that post-war rail transport could not be considered by itself alone. The consideration of all forms of transport would be involved, and they were so closely interlinked that they must be considered together. The solution of the problem seems rather to lie in the erection of some machinery for co-ordination on the lines of the "Square Deal" proposals agreed between the railways and the road organisations just so shortly before the war that there was no time to implement them by Government action. What, in fact, is required is some means of allowing competition to act, but so regulating it that its desirable quality of stimulating development is not accompanied by that cut-throat condition which reduces all the contestants to penurious inefficiency. In the finding of that "middle way" the solution of the post-war transport problem seems to lie.

A Centrifugal Pump Experiment

WITHIN the last decade or so efficiencies of centrifugal pumps have been markedly increased, and claims have been made for figures in excess of 90 per cent. under favourable circumstances of head and volume. Yet there is no doubt that some problems still remain to be solved, and there are a number of factors influencing performance about

which, though much may be suspected, little is definitely known. In this issue we reprint from the *Journal* of the American Society of Naval Engineers a paper which records some of the results obtained with a scale model of a dredger pump made in part of transparent materials. The experiments were purely of a fact-finding character in relation to the prototype of the model, and were not intended to throw light upon any fundamental feature of centrifugal pump operation. Yet, within that limitation, the results are interesting and may be provocative of thought. The model had a scale of 1 to 6, and was made partly of pyralin, one of the newer plastic materials, the physical qualities of which were found to be suitable, and in order to record the visual results photographically, stroboscopic methods were used in conjunction with the fastest lenses and photographic emulsions obtainable. In addition to the observation of the movements of silk threads mounted not only in the volute but also in the rotor itself, measurements of pressures and velocities in the volute were made by the help of Pitot tubes.

On the whole, the results of the visual tests confirm expectations. Behind each blade the water is shown by the silk threads to be in a very turbulent state, whereas in front of each blade the flow, though turbulent, is much more nearly in accordance with the theoretical relatively tangential direction. The more interesting visual result was that obtained when rubber balls were circulated through the pump. As the pump was constructed with a "whirlpool chamber," it was to be expected and it was actually observed that a ball might travel more than once right round the chamber before entering the discharge pipe. But when a "tongue" was inserted to reach from the wall of the volute almost as far as the impeller, some of the balls still continued to circulate, actually re-entering the impeller to pass under the obstruction. The shape of the tongue, it may here be observed, was not perhaps conducive to high efficiency, and, indeed, the efficiency of the pump thus fitted was less than that of the pump without the tongue. As a result of the Pitot tube measurements, it was found possible to plot "velocity contours" at a number of sections of the volute, in the suction eye and in the discharge pipe, and also to compute from this data the actual flow at these sections. It is thus found that even when running near the "duty" condition, nearly as much water circulates around the pump as enters the discharge pipe, a fact not perhaps so surprising as the author seems to think, since the pump was apparently designed for whirlpool chamber conditions, but at the same time interesting since such conditions inevitably indicate some wastage of power. At lower duties, of course, a relatively much larger quantity recirculates in this manner.

Much of the information given in the paper had been, we are inclined to think, already indicated by less direct methods or inferred from theoretical considerations. Yet that fact does not necessarily detract from the value of the paper. The author's methods could certainly be applied to a more fundamental research, and are therefore worthy of study, whilst the confirmation by direct methods of suspicions believed to be well founded is not lacking in value. Engineers are practical people. "An ounce of practice is worth a ton of theory" is a statement that could hardly be fully supported nowadays. Yet it remains a fact that, at least to an engineer, tangible or visual evidence is worth far more than theoretical proof alone.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

BEYER-GARRATT LOCOMOTIVES

Sir,—Mr. Livesay's article on running experiences with a Beyer-Garratt locomotive is of great interest. His specification for a similar locomotive is, however, open to criticism.

Cast steel frames are surely a retrograde feature, and perpetuate all the disadvantages of the bar frame. It is difficult to imagine anything less suitable for casting in steel. The fact that such frames are in use in the United States in no way nullifies this statement. If the plate frame was constructed with stretchers, motion plate, &c., welded in place, instead of using fitted bolts or rivets it could not be bettered. It may well be that modern practice does utilise welding for these connections.

The curious phenomenon of in-phase working of the front and rear engine units is of interest. It hardly seems possible that it can be explained by the fact that the blast pipe is common to all cylinders. If back pressure had any bearing on the matter it would seem more natural for the engines to exhaust in sequence, so that each cylinder full of exhaust steam was discharged when the least resistance was offered.

Incidentally, the rear or bunker unit has to exhaust against a higher back pressure than the front unit, due to the greater number of bends and length of the exhaust pipe. It would appear to be an improvement to turn the units end to end, and place the cylinders nearer to the steam and exhaust connections on the boiler unit. I am out of touch with recent Garratt developments, and this suggestion may now be embodied in current practice.

E. B. Parker.

Little Sutton, Wirral, Cheshire,
October 14th.

LINKS IN THE HISTORY OF THE LOCOMOTIVE

Sir,—From Mr. E. A. Forward's very interesting articles in recent numbers of The Engineer on the early S. and D. Railway locomotives, it seems that the first public railway company was curiously reluctant to recognise the convenience of names or numbers for engines, the more remarkable as names were usual for stage coaches and already given (at least informally) to colliery locomotives. Opposition to names on the ground of dignity would be just understandable even if it now appears an absurd austerity; but what could have been the objection to numbering once the second engine was ordered? Is it known when and how the first engine came by its name "Locomotion," and was this the first name given to it? In his "Life of George Stephenson" (second edition published by John Murray in 1857), Smiles writes (page 196): "No. 1 engine 'Active,' which was the first delivered upon the line . . ." and again (page 205): ". . . . a race actually came off between No. 1 engine, 'Active,' and one of the stage coaches. . . ." Is Smiles solitary in attributing this name to this engine?

H. W. Brady.

Dorchester, October 17th.

Sixty Years Ago

The "Great Eastern"

In our issue of October 21st, 1881, we recorded that a few days previously—on the 18th—the steamship "Great Eastern" had been submitted to auction in London by the brokers, C. W. Kellock and Co., under instructions from her owners, the Great Eastern Steamship Company. The first offer made for the ship was £20,000, and was followed by one of £25,000. There was then a pause, and the brokers stated that if there was not an immediate advance the ship would be withdrawn from sale. Two offers of £26,000 and £27,000 then followed, and finally one of £30,000. The brokers then withdrew the ship and expressed their readiness to receive offers for her sale by private treaty. There was a large attendance, but it was evident, we said, that those present did not intend to do "business." The brokers were not long in understanding their audience, and the whole proceedings lasted only twenty-five minutes. We added that the capital of the Great Eastern Steamship Company was £100,000 and that at the close of 1880 the ship's value stood in the company's books at £86,715.

The Welland Canal

In the same issue we recorded that the Welland Canal, connecting Lakes Erie and Ontario, had been successfully opened on September 16th by the passage through it of the steamer "D. A. Dickenson," a vessel of 300 tons burden, 150ft. length, 25ft. beam, and 15ft. draught. As soon as the railway from Prince Arthur's landing [Port Arthur] on Lake Superior to Winnipeg was completed, probably in the following year, grain would be carried through to Kingston, Ontario. When the canals between Kingston and Montreal had been deepened to the same depth as the Welland Canal, it would be possible for Canadian shippers to send grain from Manitoba and the North-West Territory to Europe in specially built vessels without transhipment. These grain ships would traverse more than 2000 miles of inland navigation before entering upon their ocean voyage. The distance from Chicago to Montreal by the Canadian route would be 150 miles less than from Chicago to New York by way of Buffalo and the Erie Canal, and would have sixteen fewer locks. . . . The Welland Canal cuts across the Niagara peninsula, and by-passes the Falls. The existing canal, a very much larger undertaking than the one to which our note referred, was opened in 1932.

Welded Ships.—The Institute of Welding has performed a very useful service to the shipbuilding and ship repairing industries by publishing in a collected form a bibliography on welding in shipbuilding, which contains the majority of the direct references to welding in relation to shipbuilding which have been published in the period 1930 to 1941. The first section consists of references, arranged chronologically, to books and to pamphlets included in the library of the Institute of Welding. In the second section there are references to articles which have been published in the technical journals which are received by the Institute, including a short abstract of the more important articles published in recent years. In this section attention may be drawn to articles by Mr. D. Arnott, which appeared in the *Welding Journal* of America in November, 1940, and by Mr. L. W. Delhi and Mr. M. N. Maltself, in the same journal in June, 1941, on welding in shipbuilding and all-welded ships, which are of special interest. In a third section there are given press cuttings from shipbuilding journals, together with records of launchings and other new items. The bibliography has been published in a small edition and is available at the price of 3s. per copy. Applications should be made to the Secretary, The Institute of Welding, 2, Buckingham Palace Gardens, London, S.W.1, who is also prepared to make arrangements for persons interested to obtain any of the books listed on loan or to obtain photostat copies of any desired article at the cost price ruling at the date of application.

Probability Graph Paper and its Engineering Applications

By H. RISSIK, Hons. B.Sc. (Eng.), A.M.I.E.E., M. Amer. I.E.E.

No. I

BOTH the British Standards Institution and its counterpart in America, the American Standards Association, are actively contributing to the common war effort of the two great democracies by issuing so-called emergency standard specifications to meet the peculiar needs of a wartime manufacturing programme. In this connection the request made to the American Standards Association at the end of last year by the United States War Department for the initiation of a scheme for standardising the application of statistical methods to the quality control of materials and manufactured products, and the subsequent issue by that standardising authority of two war emergency specifications dealing with this subject,[1] serve to remind us that the development of methods for the scientific control of product quality is a matter of vital importance to our war industries.

In a recent article,[2] entitled "Statistical Methods in Engineering Practice," the author gave a general account of the practical applications of statistical science to industrial engineering. In one form or another such methods have been in use in this country for a number of years in various branches of industry, notably in electric lamp manufacture, in the sampling of coal, and in the testing of textile fabrics. From the engineering standpoint, however, and particularly where mass production engineering is concerned, by far the most important use of statistical methods lies in a field where it appears to have as yet received but scant attention—the setting up of tolerance limits whose transgression at once indicates that the manufacturing process is becoming uncontrolled, *i.e.*, that unless action is taken the process will sooner or later turn out a defective product.

This neglect is all the more unfortunate in that the application of statistical methods to the quality control of a manufactured product involves quite a simple technique, no matter how abstruse or seemingly complicated may be the mathematics on which that technique is ultimately based. The trouble has been that in the past the statistician has not made it sufficiently clear to the engineer that an understanding of statistical theory, both as a science and a philosophy, is altogether unnecessary to the practical application of statistical methods. Such methods are absolutely within the competence of an up-to-date inspection organisation, which in any case is a *sine qua non* where mass production engineering is concerned, and there is therefore no reason why they should not be very widely applied. Especially is this so nowadays, when calculating machines are generally available for lightening the continuous task of computation necessary to the statistical condensation of numerical data obtained from repetitive manufacturing processes.

As a practical aid to the wider application of statistical methods to the control of product quality, an even greater boon than the modern calculating machine is the special type of graph paper known as "probability paper." It is not so very long ago—two or three decades at most—since engineers came to realise the value of logarithmic graph paper as a rapid means of solving certain types of problems. Just as this class of graph paper is known in both the "semi-log" and "log-log" forms, each of which has its own characteristic advantages, so, too, is the newer probability graph paper nowadays available in either the "arithmetic" or the "logarithmic" form. Before describing the way in which probability paper can be put to practical engineering use, however, it is necessary to indicate briefly the statistical background to such a problem as that of quality control, a problem which this latest type of graph paper enables the engineer to solve with a minimum of computational effort.

The Statistical Treatment of Quantitative Data

One of the outstanding features of statistical technique and, in fact, the main outstanding feature where engineering applications are concerned, is the basis which it provides for a systematic presentation and analysis of quantitative data. In the words of Professor R. A. Fisher, our leading authority in the field of biometrics (*i.e.*, theoretical statistics applied to biology):—"A mass of data which by its mere bulk may be incapable of entering the mind is to be replaced by relatively few quantities which shall adequately represent the whole; or which, in other words, shall contain as much as possible—ideally the whole—of the relevant information contained in the original data." Statistical method, then, is concerned primarily with summarising and giving character to quantitative data. It serves to make raw data informative, so that intelligent judgments may be passed upon them, by organising, classifying and condensing them in a systematic manner.

The first step in systematising quantitative data presented in the form of a set of unorganised numerical values, for example, a set of observed values of some measurable variable (Table I), is to arrange them in ascending order of magnitude. Such an arrangement is termed an ungrouped frequency distribution and is often of value in the initial stages of analysis, for it shows at a glance the maximum, minimum and median (*i.e.*, middlemost) values of the variable (Table II). A closer examination of this organised set of values reveals a tendency for certain individual values or, more generally, for values lying within certain ranges, to occur more frequently than others—hence the term "frequency distribution," applied to such an arrangement.

Table I.—*Tensile Strength in Pounds per Square Inch of Experimental Die Casting Alloy as Determined from Test Pieces Taken Out of Ninety-five Castings*

44,000	48,100	47,300	46,900	43,100
48,700	48,100	47,300	41,800	40,500
45,600	41,500	39,700	49,400	45,900
46,500	51,000	48,600	48,800	41,500
46,000	48,000	44,200	45,900	43,700
41,300	48,100	42,600	44,100	43,300
41,200	44,300	43,500	40,100	44,200
49,100	45,400	40,100	47,400	43,000
43,800	46,000	43,200	44,800	49,100
48,800	47,800	46,700	46,900	45,000
46,100	45,100	44,400	46,300	48,200
46,000	48,000	44,300	47,000	42,700
40,100	46,300	46,500	50,100	47,200
48,100	47,000	49,100	44,200	44,000
41,200	44,700	47,100	49,000	46,900
43,700	46,500	48,500	47,200	45,100
49,800	47,300	44,300	46,100	46,500
39,700	44,500	44,900	42,600	49,400
49,400	48,000	51,500	45,400	50,700

Table II.—*Original Data of Table I Presented as a Frequency Distribution (Grouping is Indicated by the Horizontal Divisions)*

39,700	43,300	45,100	46,900	48,200
39,700	43,500	45,100	46,900	48,500
	43,700	45,400	47,000	48,600
40,100	43,700	45,400	47,000	48,600
40,100	43,800	45,600	47,100	48,700
40,100	44,000		47,200	
40,500	44,000	45,900	47,200	48,800
41,200	44,100	45,900		49,000
41,200	44,200	46,000	47,300	49,100
	44,200	46,000	47,300	49,100
41,300	44,200	46,000	47,300	49,100
41,500		46,100	47,400	49,400
41,500	44,300	46,100	47,800	49,400
41,800	44,300	46,300	48,000	49,400
42,600	44,300	46,300	48,000	49,800
42,600	44,400	46,500	48,000	50,100
42,700	44,500	46,500	48,100	
	44,700	46,500	48,100	50,700
43,000	44,800	46,500	48,100	51,000
43,100	44,900	46,700	48,100	51,500
43,200	45,000	46,900		

Minimum = 39,700 Median = 46,000 Maximum = 51,500

This immediately suggests the next step in systematising the raw data, that of classification, which consists in grouping the organised set of values into a number of successive classes, each class representing a definite range in magnitude of the observed variable. Such an arrangement is termed a grouped frequency distribution, and shows at a glance the frequency of occurrence of the observed values grouped together in any class (Table II—Horizontal Divisions). The interval, along the scale of measurement, occupied by each class is termed a cell. Each cell is in practice defined by the magnitude of the variable coinciding with the mid-point rather than with either of the two boundaries of the cell. The range of magnitudes lying between the cell boundaries (*i.e.*, between the lower and upper limits of magnitude of the variable within which lie the group of values pertaining to that particular class) is termed the cell interval. It is customary to make all the cell intervals the same, and to choose the cell boundaries halfway between two possible values of the variable.[3]

The final step in systematising the original data follows almost automatically from an examination of the grouped frequency distribution. It consists in condensing the detailed information contained therein by treating all observed values lying in any cell as having the same magnitude, viz., the particular value of the variable corresponding to the cell mid-point. The grouped frequency distribution is thus reduced to a simple frequency tabulation which gives the relationship between a relatively small number of equally spaced values of the variable x—the successive cell mid-points—and the frequencies with which they occur (Table III). The number of observations grouped together in any cell is termed the cell frequency and is denoted by f; while their summation Σf over all the cells of the frequency distribution

[1] American Defense Emergency Standards, Nos. Z1.1, 1941; *Guide for Quality Control*; and Z1.2, 1941: *Control Chart Method of Analysing Data*.

[2] This article was published in THE ENGINEER at the end of 1940, and appeared in four parts, viz.:—
Part I: Fundamental Aspects of Statistical Technique (November 29th).
Part II: Quality Control in Production Engineering (December 6th and 13th).
Part III: Quality Standards in Purchasing Specifications (December 20th).
Part IV: Sampling Inspection in the Control and Standardisation of Quality (December 27th).

[3] For example, if the observations are recorded to the nearest ten units of measurement, the cell boundaries will have numerical values whose last digit is in each case 5; again, if the observed values are taken to the nearest 0·001, then the cell boundaries should be multiples of 0·0005. In the case of Tables II and III, the common cell interval is 1500 lb. per square inch and the cell boundaries have values whose last two digits are 50.

—that is, the total number N of the observed values of the variable x—is the total frequency.

The number of cells into which any given frequency distribution should be subdivided is largely a matter of judgment and its choice must be guided by the following considerations :—

(*a*) The number of cells should be such that one can treat all the observations assigned to any cell, without serious error, as if their values were equal to that value corresponding to the cell mid-point.

(*b*) A large number of cells tends to confuse the general picture of a frequency distribution and to emphasise sampling fluctuations.

(*c*) Too small a number of cells generally leads to appreciable inaccuracy in subsequent statistical computation, arising from the systematic error due to grouping introduced in accordance with (*a*) above.

Experience goes to show that these three conditions will generally be met if the number of cells lies between 10 and 20.

For some purposes the number of observations having a value less than, or more than, a given value of the variable is of interest. This consideration leads to the formation of a so-called cumulative frequency table, which records the accumulated frequency of the several cells up to successive cell boundaries (Table III). Such a table is built up

TABLE III.—*Frequency Tabulation of the Original Data as Presented in Table II*

Cell No.	Cell mid-point.	Absolute frequency.		Cell bound'y.	Cumulative frequency.	
		f.	%		Σf.	%
				38,250	0	0
1	39,000	2	2·1			
				39,750	2	2·1
2	40,500	6	6·3			
				41,250	8	8·4
3	42,000	7	7·4			
				42,750	15	15·8
4	43,500	14	14·7			
				44,250	29	30·5
5	45,000	14	14·7			
				45,750	43	45·2
6	46,500	22	23·2			
				47,250	65	68·4
7	48,000	17	17·9			
				48,750	82	86·3
8	49,500	10	10·5			
				50,250	92	96·8
9	51,000	3	3·2			
				51,750	95	100

from the tabulation of absolute frequencies f by successively adding the individual cell frequencies f_1, f_2, f_3 . . . f_k, and entering the cumulative sums f_1, f_1+f_2, $f_1+f_2+f_3$, &c., opposite the x values of the corresponding cell boundaries. The cumulative frequency Σf for any cell is thus the total frequency up to the upper boundary of that cell. It is, in effect, the number of observed values of the variable x whose magnitude is less than the value of corresponding to the upper cell boundary.

In the same way, by tabulating the differences between the total frequency N and these cumulative frequencies Σf, the corresponding " more than " table may be formed. Or it may be built up directly by cumulating the frequencies backwards from the end of the absolute frequency tabulation. In either case the cumulative frequencies so obtained are the total frequencies down to the lower boundaries of the successive cells, *i.e.*, each is the number of observed values of the variable x whose magnitude is more than the value of corresponding to the lower boundary of the cell in question.

A grouped frequency distribution or, to be precise, its corresponding frequency tabulation, may be represented graphically as a stepped diagram in which the height of each step is the cell frequency, the step width is the cell interval, and each successive step corresponds to a cell. Such a diagram is termed a histogram and is, in effect, a graph of absolute frequency f plotted against the variable x, but a graph whose discontinuities are an acknowledgment of the fact that the several values of x grouped together in each cell are not concentrated at the cell mid-point, but are in actuality spread out over the cell interval. Fig. 1 (*a*) shows the histogram of the absolute frequency tabulation given in Table III.

The corresponding graph of the cumulative frequency tabulation (" less than " table) is shown in Fig. 1 (*b*) and is known as an ogive. A little consideration will show that each ordinate of Fig. 1 (*b*) is given by the sum of the areas of the rectangular steps of the histogram of Fig. 1 (*a*) up to the cell boundary at which the ordinate is erected. In other words, the number of observed

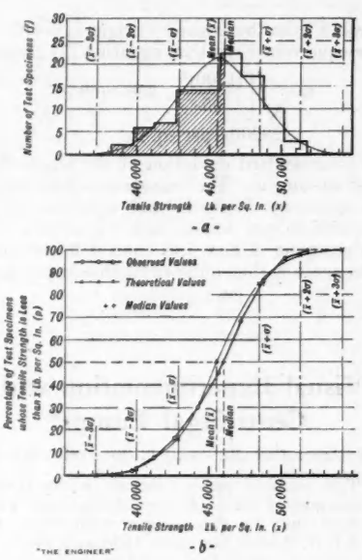

Number of Test Specimens (f)
Tensile Strength Lb. per Sq. In. (x)
- a -
Observed Values
Theoretical Values
Median Values
Percentage of Test Specimens whose Tensile Strength is Less than x Lb. per Sq. In. (p)
Tensile Strength Lb. per Sq. In. (x)
"THE ENGINEER"
- b -

FIG. 1—HISTOGRAM AND OGIVE

values of the variable x whose magnitude is less than some particular value x_m, say, is given by the area under the histogram up to the ordinate at $x=x_m$.

Generally speaking, if a frequency distribution can be represented by a smooth curve —known as a frequency curve—then the aggregate frequency in the range $x_a<x<x_b$ will be given by the area under the curve between the ordinates erected at $x=x_a$ and $x=x_b$. Since the total area under the curve is N, the total number of observations comprising the frequency distribution, it is seen that the relative frequency p (*i.e.*, the proportion of these observations) in the range $x_a<x<x_b$ is given simply by the ratio of the area between $x=x_a$ and $x=x_b$ to the total area under the curve. This unique property of frequency curves is the corner-stone of the statistical building which the engineer can construct for himself—a building as elegant as it is useful.

THE CHARACTERISTICS OF A FREQUENCY DISTRIBUTION

Although the grouped frequency distribution, whether in tabular or histographic form, constitutes the most systematic presentation of quantitative data, the information given therein may be still further condensed by making use of certain characteristics of the distribution. In general, three such characteristics are at once apparent from an inspection of the histogram, viz.:—

(1) The tendency for the observations[4] to be distributed about some central value.

(2) The extent to which the observations are spread out on either side of this central value.

(3) The degree in which the distribution lacks symmetry with respect to the central value.

These three characteristics are defined respectively by the mean, the standard deviation, and the skewness of the frequency distribution. For reasons which will become apparent later, only the first two characteristics are of any importance in the engineering applications of statistical technique, so that there is no need here to discuss the skewness of a distribution.[5]

In the order of their importance from the point of view of a statistical analysis of quantitative data, the three measures of the central tendency of a frequency distribution are :—

(*a*) *The Mode.*—This is the popular " average " of journalism and uninformed statistical pronouncements, epitomised in such a phrase as " the average man." It is simply that value which occurs most frequently, and its chief service is in characterising a type. Mathematically it is very difficult to define, but it is at once evident from the general shape of a histogram. If a frequency distribution could be represented by a smooth curve, then the mode would be the abscissa of the highest point on the curve.

(*b*) *The Median.*—This may be defined as the middlemost or central value of the variable when the observations are arranged in order of magnitude (ungrouped frequency distribution). In other words, it is that value which is so situated that greater and smaller values occur with equal frequency. Considering the histogram of a frequency distribution, the median is the x-value of the ordinate which divides the area under the histogram into two equal parts. In general, the median of a frequency distribution is that value of the variable x for which the cumulative frequency Σf is half the total frequency N.

(*c*) *The Mean.*—This is the true average or arithmetic mean of the N observed values of x defined by

$$\bar{x}=\frac{1}{N}(x_1+x_2+x_3+\ldots+x_N)=\frac{1}{N}\sum_1^N x \quad . \quad (1)$$

in the case of an ungrouped frequency distribution, and by

$$\bar{x}=\frac{1}{N}(f_1x_1+f_2x_2+f_3x_3+\ldots+f_kx_k)$$
$$=\frac{1}{N}\sum_1^k fx \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in the case of a grouped frequency distribution, for which f is the cell frequency, k the number of cells, x the value of each successive cell mid-point, and N is the total frequency, viz.,

$$N=f_1+f_2+f_3+\ldots+f_k=\sum_1^k f \quad . \quad . \quad (3)$$

The mean of a frequency distribution is by far the most widely used measure of central tendency, for its algebraic treatment is particularly easy, while, at the same time, it is relatively stable, *i.e.*, it is not much affected by sampling fluctuations.

[4] The term " observation " is here rather loosely used to indicate what the statistician calls a " variate," that is, a numerical value connoting an individual magnitude of the variable whose frequency distribution is under consideration. This nomenclature will be adhered to in what follows.

[5] For a practical and altogether readable treatment of frequency distributions and their characteristics, see J. F. Kenney, " Mathematics of Statistics," Part I (Chapman and Hall, London, 1940). This is by far the best elementary work on the methodology of statistical science which has so far been published.

A little consideration of equation (2) in conjunction with the histogram of Fig. 1 (*a*) shows that the products $f_1x_1, f_2x_2, \ldots f_kx_k$ are, in the language of mechanics, the "moments" of the cells about the zero axis $x=o$. Hence x, the mean of the N observations, is the abscissa of the centroid of the histogram—a concept which makes a ready appeal to the engineering mind. A short cut to the computation of $\bar{x}$ in the case of a frequency tabulation such as that of Table III is to choose some arbitrary origin $x=x_o$ (preferably the mid-point of the middlemost cell, or of one of the two end cells) and to record the deviations of the successive values $x_1, x_2, \ldots x_k$ from x_o in terms of the number of cells rather than in terms of the actual variable x. If these successive deviations be denoted by $t_1, t_2, \ldots t_k$ and if the cell interval be I units, then for any particular cell $x=x_o+\mathrm{I}\,t$. Equation (2) thus gives

$$\bar{x}=x_o+\frac{\mathrm{I}}{\mathrm{N}}\sum_1^k f\,t \quad . \quad . \quad . \quad . \quad (4)$$

The corresponding tabulation for the example of Table III is given in Table IV. The moments $f\,t$ are given in the fifth column of the table, from which $\Sigma f\,t=44$. Also we have $\mathrm{N}=\Sigma f=95$. With an arbitrary origin at $x_o=45{,}000$ and a cell interval $\mathrm{I}=1500$, equation (4) thus gives

$$\bar{x}=45{,}000+\frac{1500}{95}\,(44)=45{,}695\text{ lb. per sq. in.}$$

as the mean tensile strength of the ninety-five test specimens. The true mean as given by Table II and equation (1) is $\bar{x}=45{,}700$ lb. per square inch. The error due to grouping is in this case less than 0·01 per cent. and is thus quite negligible in practice. (The median value is seen from Fig. 1 (*b*) to be 46,060 lb. per square inch, which differs by a mere 0·13 per cent. from the true value (46,000) given by Table II.)

The almost universal measure of the spread or dispersion of the observations about this central value is what is known as the standard deviation. It is defined as the root-mean-square value of the deviations of the N observed values of x from their mean value $\bar{x}$, and is denoted by σ. Thus

$$\sigma=\sqrt{\left[\frac{1}{\mathrm{N}}\left\{(x_1-\bar{x})^2+(x_2-\bar{x})^2+\ldots+(x_\mathrm{N}-\bar{x})^2\right\}\right]}=\sqrt{\left[\frac{1}{\mathrm{N}}\sum_1^\mathrm{N}(x-\bar{x})^2\right]}=\sqrt{\left[\left(\frac{1}{\mathrm{N}}\sum_1^\mathrm{N}x^2\right)-\bar{x}^2\right]} \quad . \quad . \quad . \quad (5)$$

in the case of an ungrouped frequency distribution, and

$$\sigma=\sqrt{\left[\frac{1}{\mathrm{N}}\left\{f_1(x_1-\bar{x})^2+f_2(x_2-\bar{x})^2+\ldots+f_k(x_k-\bar{x})^2\right\}\right]}=\sqrt{\left[\frac{1}{\mathrm{N}}\sum_1^k f(x-\bar{x})^2\right]}=\sqrt{\left[\left(\frac{1}{\mathrm{N}}\sum_1^k f\,x^2\right)-\bar{x}^2\right]} \quad . \quad . \quad . \quad . \quad (6)$$

in the case of a grouped frequency distribution with k cells, and total frequency $\mathrm{N}=\Sigma f$ as given by (3). A little consideration of equation (6) in conjunction with the histogram of Fig. 1 (*a*) will show that the products $f\,x^2$ are the "second moments" of the cells about the zero axis $x=o$; while the products $f(x-\bar{x})^2$ are the corresponding moments about an axis through the "centroid" $x=\bar{x}$. In the language of mechanics, therefore, the standard deviation σ is simply the "radius of gyration" of the frequency histogram—a concept which again makes a ready appeal to the engineering mind. The same computation short cut as was taken in the case of the mean value $\bar{x}$ is available in the calculation of the standard deviation. Using the nomenclature of equation (4), one finds from equation (6)

$$\sigma=\sqrt{\left[\left(\frac{\mathrm{I}^2}{\mathrm{N}}\cdot\sum_1^k f\,t^2\right)-(\bar{x}-x_o)^2\right]} \quad . \quad (7)$$

Referring to the frequency tabulation exemplified by Table III, the second moments $f\,t^2$ are given in the sixth column of Table IV, from which $\Sigma f\,t^2=356$. The deviation of the

Table IV.—*Computation of $\bar{x}$ and σ*

Cell No.	x.	t.	f.	$f\,t$.	$f\,t^2$.
1	39,000	−4	2	− 8	32
2	40,500	−3	6	−18	54
3	42,000	−2	7	−14	28
4	43,500	−1	14	−14	14
5	x_o=45,000	0	14	0	0
6	46,500	1	22	22	22
7	48,000	2	17	34	68
8	49,500	3	10	30	90
9	51,000	4	3	12	48
Cell interval: I=1500		Totals:	$\Sigma f=95$	$\Sigma f\,t=44$	$\Sigma f\,t^2=356$

mean $\bar{x}$ from the arbitrary origin x_o is 695 lb. per square inch, so that equation (7) gives

$$\sigma=\sqrt{\left[\frac{(1500)^2}{95}\cdot 356-(695)^2\right]}$$

$=2820$lb. per sq. in.

as the standard deviation of the ninety-five test specimens. The true standard deviation as given by Table II and equation (5) is $\sigma=2785$ lb. per square inch. The error due to grouping is here less than 0·9 per cent. and again is thus quite negligible in practice.

(To be continued)

Visual Experimentation with Centrifugal Pumps*

By Lieut.-Com. HOWARD L. COOPER, U.S.N.R.

The ensuing paper presents a descriptive discussion of some of the experimental work carried out by the author while with the U.S.E.D. during the years 1936 and 1937. It concerns a fact-finding model study in connection with a 28in. dredger pump. This type of pump has given excellent service on various Government projects.

Description of Models and Lay-out

A model scale of 1 : 6 was selected as the most satisfactory solution to the combined requirements of transparency, economy, simplicity of construction, dynamometer-power limitation, and similitude requirements. The volute was constructed of heavy pyralin, mounted in a rigid cast aluminium frame. The impellers consisted of heavy pyralin shrouds securely mounted on cast aluminium spiders, which, in turn, were keyed on the pump shaft. Pyralin is a plastic material composed of cellulose nitrate, possessing excellent transparency and fulfilling the physical requirements.

The volute described above was built in accordance with the latest design of a 28in. Army engineer's dredger pump, and for identification purposes is designated as pump casing A. For similar reasons, the designation impeller A was given to the model impeller corresponding to the latest design used in this pump. Both pump casing A and impeller A are shown in Fig. 1.

Impeller B was adapted to the 1 : 6 dredger pump model from an earlier design for the 1 : 4 hopper dredger pump model. The outstanding difference between the two impellers is the difference in the exit angles. In the case of impeller A, the exit angle of the fluid is 49 deg. 40 min., while that of impeller B is 63 deg. 30 min. In both cases the entrance angles of the impeller blades are 42 deg. 30 min.

The exit angle of impeller C is identical with that of impeller B. However, this impeller was designed to give a much more gradual progression of area between the suction nipple and periphery of the impeller.

In the complete testing set-up no valves existed in either the suction or discharge lines. The model was operated with the water surface below the centre line of the pump in conformity with the prototype. Nozzles (or orifices) were used at the end of the discharge line to simulate a wide range of pipe line lengths. Discharge measurements were made either with a weir or volumetric tank, in addition to nozzles or orifices, and checked against area times velocity results.

Velocity measurements were made with a modified Iowa type pitot tube, with a streamlined velocity orifice. In order to reduce the effect of oblique currents from the impeller on pressure readings, the usual single pressure orifice at the bottom was replaced with two pressure orifices at the sides. The velocity was

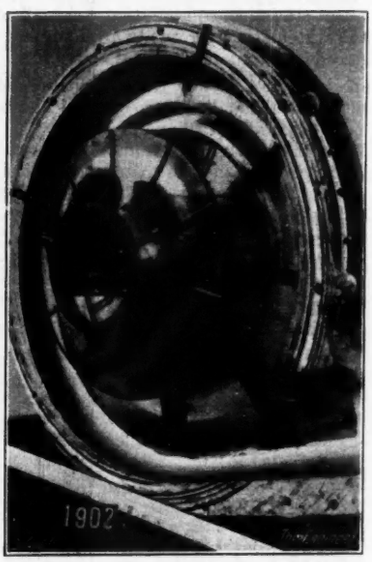


Fig. 1—Pump and Impeller "A"

read directly from differential gauges calibrated by the formula $v=6\cdot4\,\mathrm{H}^{\cdot526}$ which was determined at the Institute of Hydraulic Research at Iowa City.

All pressure measurements were determined with the aid of manometers, using water manometers for low pressures and mercury manometers for high pressures.

Velocity and Pressure Distribution

Eight sections were selected for velocity observations, one in the suction nipple, another in the discharge nipple, and the remaining six in the volute. The location of the sections was governed by the construction features of the model and the anticipated relative importance of the observations. Two or more openings were provided in each section for inserting the pitot tube; velocity readings were taken at ½in. intervals in each of the twenty-two traverses for which openings had been provided.

Using pump casing A and impeller A, velocity distributions were obtained from observations at all points and plotted as velocity contours illustrated in Fig. 2. A study of this exhibit indicates several points of particular interest. In most sections the general effect of increasing the discharge is to lower the velocity gradient along radial traverses. This is especially noticeable in section G G, where the average velocity in the bottom of the volute increases over 50 per cent. while the velocities near the impeller decrease slightly. The flow in the discharge nipple is poorly distributed for small orifices (long pipe lines), and, in the case of orifice 2 (9925ft.), was actually reversed in the bottom of the nipple.

A comparison of the observed velocities in the suction and discharge nipple and those in the volute brought forth one of the most important discoveries obtained in the course of the experimental work. The comparatively

* American Society of Naval Engineers.

low velocities in the suction nipple are increased about six times in the volute only to be slowed down greatly in the discharge nipple. After computing the quantities of flow through each section, it is concluded that considerable recirculation of fluid occurs within the pump. A graphical illustration of this phenomenon for each section is given in Fig. 2.

In pumps of this nature where the fluid is loaded with a high percentage of abrasive material, both recirculation and high volute velocities are responsible for excessive costly wear. These factors will be further discussed in relation to efficiency and design features.

Pressure distributions were obtained for the operating conditions of the velocity experiments, as stated for runs 2 to 5 of Fig. 2. Pressures were measured at the inner surface of each opening provided for the velocity measurements, and also at additional openings provided especially for pressures.

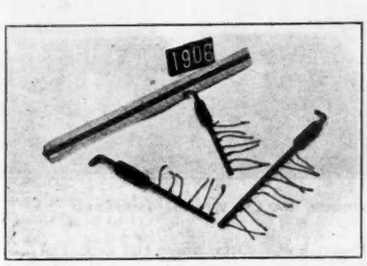


FIG. 3—FLOW DIRECTION INDICATORS

Observation indicated the existence of a pressure gradient along radial lines with a slope inverse to that of the velocity gradient as expected. Small losses of pressure head, especially noticeable between sections E E and F F, point to some unnecessary conversions to velocity head. No marked difference was noted between pressure distributions with impellers A and B.

It has been commonly believed that the pressures throughout the back clearance space are approximately equal to the pressures at the outlet of the impeller. The laboratory results obtained in this case have not substantiated the above belief; on the contrary, they have indicated that, at least for the conditions found on dredger pumps, the pressures in the back clearance space in the vicinity of the axis of the pumps are much closer to those near the impeller eye than they are to the volute pressures.

OBSERVATION OF FLOW CONDITIONS

Direction indicators, as shown in Fig. 3, were used to study flow direction in the nipples and in the volute. These indicators consisted of stout silk threads fastened to streamlined brass rods which could be inserted or removed at will from the pump casing. Similar indicators were fastened in the interior of the impeller, between the shrouds, as illustrated in Fig. 4. These were removable also. Rubber balls with specific gravity slightly lower than that of water proved of assistance in studying flow conditions within the impeller and the volute. Other means of studying flow conditions within the volute, nipples, and clearance spaces, such as air bubbles and permanganate solution, were utilised.

The speed of rotation and the magnitude of the velocities of flow, especially within the impeller, were much too great for the human eye to follow. It was therefore necessary to use some means of arresting the motion. This was accomplished by means of an electrical stroboscope. For this special application the stroboscope was actuated by a mechanical contactor mounted on the dynamometer shaft, thus causing one flash of light for each revolution of the pump. Since the impeller was always illuminated in exactly the same angular position, it appeared to be standing still. Therefore, any movable object between the vanes which did not appear to stand still, gave an indication of the flow conditions or turbulence. Even for visual observations, conditions required the equipment to be powerful in effect on account of the great absorption of light by the total thickness of about 2in. of pyralin and 4in of water.

In order to obtain permanent records of flow conditions within the pump, it was necessary to develop suitable photographic equipment for both still and motion pictures. A special ultra-high-speed camera was coupled with a stroboscope of extreme power and frequency. Since the duration of a stroboscopic flash is in the order of 1/100,000 of a second, it will be readily understood that flashes of extreme intensity and actinic value had to be provided in order to obtain a satisfactory impression, even on the fastest emulsions available, and to be capable of doing this after having penetrated the highly absorptive pyralin and water.

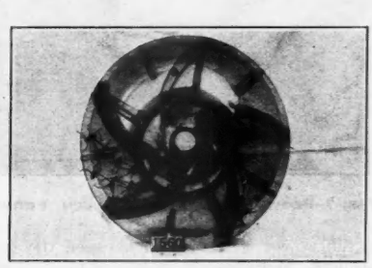
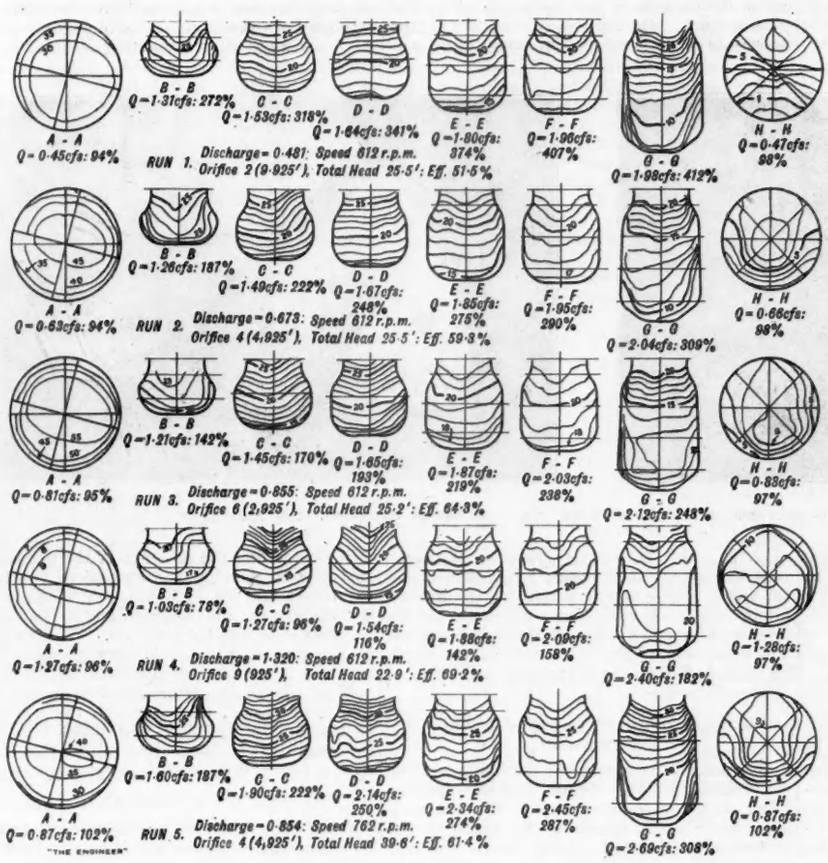
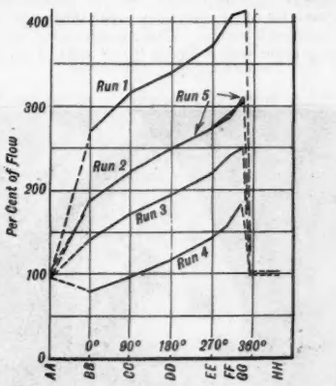


FIG. 4—DIRECTION INDICATORS IN IMPELLER

These circumstances dictated extensive research and experimental work, involving the fastest lenses, fastest emulsions, and the most advanced methods of hypersensitising and of development. A simplified form of strobo-


A - A
Q = 0·45cfs: 94%
B - B
Q = 1·31cfs: 272%
C - C
Q = 1·53cfs: 318%
D - D
Q = 1·64cfs: 341%
E - E
Q = 1·80cfs: 374%
F - F
Q = 1·96cfs: 407%
G - G
Q = 1·98cfs: 412%
H - H
Q = 0·47cfs: 98%
RUN 1. Discharge = 0·481: Speed 612 r.p.m. Orifice 2 (9·925'), Total Head 25·5': Eff. 51·5%
A - A
Q = 0·63cfs: 94%
B - B
Q = 1·26cfs: 187%
C - C
Q = 1·49cfs: 222%
D - D
Q = 1·67cfs: 248%
E - E
Q = 1·85cfs: 275%
F - F
Q = 1·95cfs: 290%
G - G
Q = 2·04cfs: 309%
H - H
Q = 0·66cfs: 98%
RUN 2. Discharge = 0·673: Speed 612 r.p.m. Orifice 4 (4,925'), Total Head 25·5': Eff. 59·3%
A - A
Q = 0·81cfs: 95%
B - B
Q = 1·21cfs: 142%
C - C
Q = 1·45cfs: 170%
D - D
Q = 1·65cfs: 193%
E - E
Q = 1·87cfs: 219%
F - F
Q = 2·03cfs: 238%
G - G
Q = 2·12cfs: 248%
H - H
Q = 0·83cfs: 97%
RUN 3. Discharge = 0·855: Speed 612 r.p.m. Orifice 6 (2,925'), Total Head 25·2': Eff. 64·3%
A - A
Q = 1·27cfs: 96%
B - B
Q = 1·03cfs: 78%
C - C
Q = 1·27cfs: 96%
D - D
Q = 1·54cfs: 116%
E - E
Q = 1·88cfs: 142%
F - F
Q = 2·09cfs: 158%
G - G
Q = 2·40cfs: 182%
H - H
Q = 1·28cfs: 97%
RUN 4. Discharge = 1·320: Speed 612 r.p.m. Orifice 9 (925'), Total Head 22·9': Eff. 69·2%
A - A
Q = 0·87cfs: 102%
B - B
Q = 1·60cfs: 187%
C - C
Q = 1·90cfs: 222%
D - D
Q = 2·14cfs: 250%
E - E
Q = 2·34cfs: 274%
F - F
Q = 2·45cfs: 287%
G - G
Q = 2·69cfs: 308%
H - H
Q = 0·87cfs: 102%
RUN 5. Discharge = 0·854: Speed 762 r.p.m. Orifice 4 (4,925'), Total Head 39·6': Eff. 61·4%
"THE ENGINEER"



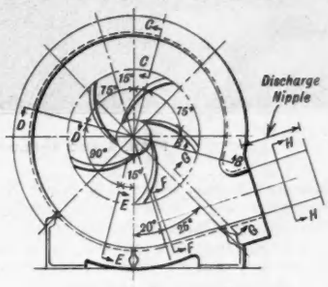


FIG. 2—VELOCITY CONTOURS IN SUCTION NIPPLE, VOLUTE AND DISCHARGE NIPPLE

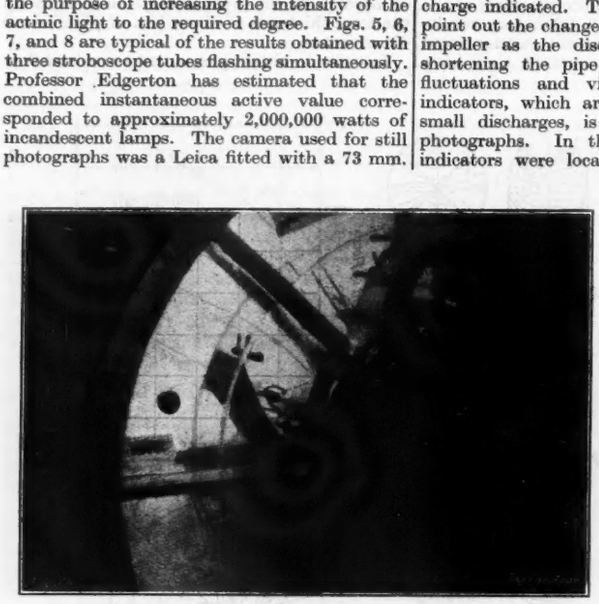
scopic circuit, developed by Professor H. E. Edgerton, of the Massachusetts Institute of Technology, proved to be the most promising source of stroboscopic light. For this circuit, special tubes were designed and constructed for the purpose of increasing the intensity of the actinic light to the required degree. Figs. 5, 6, 7, and 8 are typical of the results obtained with three stroboscope tubes flashing simultaneously. Professor Edgerton has estimated that the combined instantaneous active value corresponded to approximately 2,000,000 watts of incandescent lamps. The camera used for still photographs was a Leica fitted with a 73 mm. Hektor f : 1·9 lens, using E K Super X film. Photographs were taken at a distance of approximately 34in. with the lens wide open.

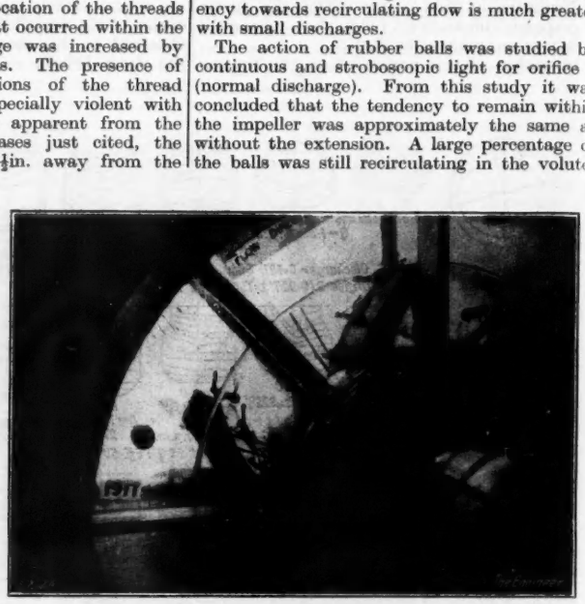
Flow conditions were generally of a complicated nature, and at times were subject to violent fluctuations and changes, making an accurate description difficult.

The average directions of flow in the volute were obtained for impellers A and B, using orifice 6 at 612 r.p.m. by observation of the threads used as indicators. The general flow direction suggested a clockwise spiralling of the stream to an observer looking in the same direction as the flow occurred. The individual thread indicators fluctuated rapidly over ranges varying from 15 deg. to 45 deg. However, no striking differences were noticed between the two impellers. With both impellers the most severe fluctuations occurred in section B B. Rubber balls sent through the pump frequently struck the tongue and were often observed to travel around the volute several times before entering the discharge nipple.

Fig. 7, taken of section C C (top of front head of pump), shows three pairs of threads directed radially inward, indicating a fairly strong flow through the clearance space toward the centre of the pump. Observation of the flow through the clearance space at the back head of the pump resulted in like conclusions. In both cases these conclusions were verified with injection of permanganate solution into both clearance spaces.

Figs. 5 and 6 illustrate typical flow directions within impeller A for the two extremes of discharge indicated. The location of the threads point out the changes that occurred within the impeller as the discharge was increased by shortening the pipe lines. The presence of fluctuations and vibrations of the thread indicators, which are especially violent with small discharges, is not apparent from the photographs. In the cases just cited, the indicators were located ¼in. away from the vane surface. A second group of indicator rods was spaced at the third intervals between the vanes. These also demonstrated the gradual improvement in the flow conditions as the discharge increased. Visual observation of the flow directions within impeller B brought forth no striking differences in the flow conditions of the two impellers.





FIGS. 5 AND 6—FLOW DIRECTIONS WITHIN IMPELLER "A" BETWEEN SECTIONS C C AND D D

The Experiment with a Tongue Extension

By radically reducing the minimum area of the volute near the tongue, it was hoped to bring about an improvement in the efficiency as a result of an extensive reduction in the volume of recirculated water. The reduction in area was accomplished by inserting a rubber extension to the tip of the tongue, as shown in Fig. 9.

The pump characteristic with the tongue extension in place was determined for a model speed of 612 r.p.m. Fig. 9 represents a comparison of this characteristic with that of the pump under same operating conditions, but without tongue extension. It will be noted that for the condition with tongue extension both heads and efficiencies obtained were decidedly lower throughout the range. This striking result indicates that the turbulence losses exceeded any possible gains due to the reduction of the quantity termed recirculating flow. It is observed that tongue extension causes less change in characteristic for large discharges than for small ones. This seems reasonable, considering the fact that the tendency towards recirculating flow is much greater with small discharges.

The action of rubber balls was studied by continuous and stroboscopic light for orifice 6 (normal discharge). From this study it was concluded that the tendency to remain within the impeller was approximately the same as without the extension. A large percentage of the balls was still recirculating in the volute, notwithstanding the presence of the extension. In order to pass by the extension, the balls re-entered the impeller between section F F and the tongue, and then returned to the volute between sections B B and C C. With the aid of permanganate solution, strong eddies and extreme tubulence was observed in the front half of the volute after the flow passed the tongue extension, while through the rear half of the volute the flow was parallel to the curvature. This observation substantiated the reasons for the drop in efficiency stated above.

Factors Influencing Efficiency

Data from which efficiencies were computed were obtained for model speeds ranging between 250 and 980 r.p.m. Since the actual observations could not always be made at exactly the desired speed, it was therefore necessary to make adjustments for this factor before making any comparisons. These adjustments were based on the fundamental principles of pump design or affinity laws which are stated below. The discharge Q varies with the speed N, and the head H varies with the square of the speed N. As the water horsepower, W.H.P., is a function of both Q and H, it varies as the cube of the speed N. It is assumed that brake horsepower, B.H.P., also varies with the cube of the speed N. Though not strictly true, this results

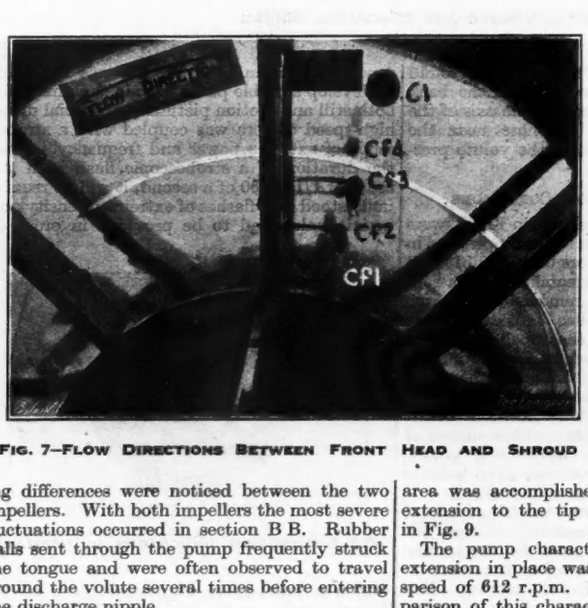


FIG. 7—FLOW DIRECTIONS BETWEEN FRONT HEAD AND SHROUD

FIG 8.—RUBBER BALLS WITHIN IMPELLER

in no appreciable error when considering the small variations in speed involved.

The efficiency data obtained at 612 r.p.m. with impellers A, B, and C, are shown graphically in Fig. 10. The operating conditions were practically identical so that their influence may be neglected when comparing the different designs. The slight irregularity in the Q H characteristic for impeller A does not exist with impeller B. The rising characteristic and large hump in the Q H characteristic of impeller A may be conducive to less favourable operation than for impeller B under certain conditions. Impeller B operates at a definitely higher efficiency than impeller A. However, impeller B has the disadvantage that it must be operated at a slightly higher speed to obtain the same discharge through a given pipe line. The efficiency of impeller C is definitely below that of the other impellers for high discharges, and therefore would require a much higher speed for a given condition of operation.

The influence of mechanical losses on the values of brake horsepower and efficiency is much more pronounced in the model than in the prototype. This is especially true at low speeds and discharges, accounting essentially for the low model efficiencies at low speeds.

The effect of increasing the speed or discharge is to reduce the percentage of water horsepower which is lost, due to hydraulic friction. This trend is apparent in both model and prototype data though to a different degree in each.

The influence of suction head, as indicated by the model data, was considerably greater than expected. For vacuums of 10in. of mercury or less or positive inlet pressures, the effect of suction head on efficiency was not measurable. However, for suction heads greater than 10in. of mercury, a large quantity of air appeared in the pump and the efficiency became increasingly dependent upon suction head, although most of the data were for vacuums much too low to cause cavitation. This phenomenon was no doubt partially a result of model construction, as for high suction heads it was extremely difficult to eliminate small air leaks in the numerous joints between metal and pyralin. The jet through the measuring orifice discharged directly into the atmosphere, creating conditions favourable to air saturation of the water. Also the presence of a check valve with rather high constriction at the entrance of the suction line caused a sudden drop in pressure at that point. It is believed that these last two factors affected the results of high vacuum comparisons on account of excessive liberation of air out of solution.

An analysis was made of the effect of flow distribution and recirculation upon efficiency with impeller A. The average velocity through each section was determined by measuring with a planimeter the area between each pair of iso-velocity lines on the original full-scale drawings of Fig. 2. These data were then used to compute the flow through each section, both in cubic feet per second and percentage of measured pump discharge. To do this it was necessary to choose a point from which it was assumed that all flow from the impeller at that point would circulate around the volute a full 360 deg. This was done by extending the upper line of the discharge nipple to meet the periphery of the impeller. This occurred approximately at section F F. If there were no recirculation in the pump, the flow past section F F would be equal to the measured pump discharge. Thus the quantity of flow that may be charged to recirculation is equal to the difference between the computed flow past section F F and the pump discharge measured by the orifice. It is realised that these assumptions are somewhat arbitrary as it was not possible to definitely determine the point at which the discharge from the impeller flowed directly into the discharge stream. It is also probable that the position of this point varies with the pump discharge.

As illustrated in Fig. 2, runs 1, 2, 3, and 4 are for the same speed of 612 r.p.m., but with successively larger discharges. The pump discharge measured by the orifice is taken as 100 per cent. In sections B B and C C it will be noticed that as the pump discharge increased, the flow through these sections decreased, indicating a rapidly decreasing percentage of recirculating water. The highest efficiency recorded for the velocity experiments was obtained with the largest of the four orifices, corresponding to the shortest pipe line. The flow conditions for this orifice are the most uniform of the four runs. The table below

	Flow through B B in per cent. of pump discharge. Per cent.	Pump efficiency in per cent. Per cent.
Run 1 with orifice 2 (9925ft.)	272	51·5
Run 2 with orifice 4 (4925ft.)	187	59·3
Run 3 with orifice 6 (2925ft.)	142	64·3
Run 4 with orifice 9 (925ft.)	78	69·2

demonstrates the effect of unfavourable working conditions of the longer pipe lines, and suggests the possibilities of further improvements in design with the purpose of improving flow conditions and quantitatively reducing recirculation and thereby obtaining higher efficiencies.

Runs 3 and 5 were made with the same pump discharge at different speeds on account of the different pipe line lengths used (see Fig. 2). From these it is concluded that the effect of speed upon the velocity distributions in the nipples is practically negligible. Due to the higher impeller speed, the average velocities in the volute increased, thus increasing the percentage of recirculating water from 142 to 187 per cent. A corresponding drop in efficiency from 64·3 to 61·4 per cent. occurred.

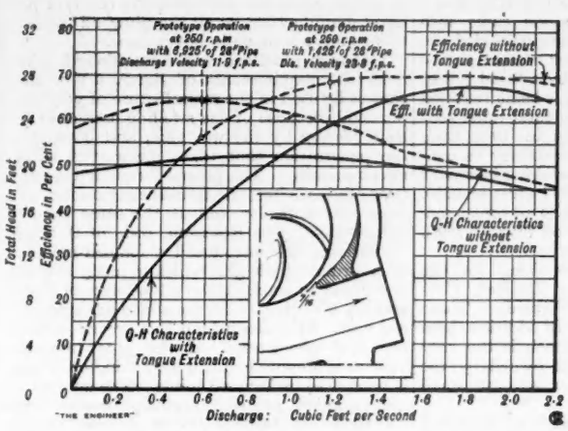
A comparison of flow conditions within the impeller and the efficiency data leads to the logical assumption that the extent of deadwater zones within an impeller has a pronounced influence on the relative efficiency of impellers. A similar conclusion was reached by Taijiro Kasai Kogakushi after a study of the exit velocities and slip coefficient in centrifugal pumps. He states "another interesting fact can be found about the characteristic curves; that the greater the size of the deadwater zones in the impeller passages at the discharge for N_{max}, the lower the velocity of N_{max} becomes." N_{max} is the maximum efficiency obtainable from a given design at a given speed.

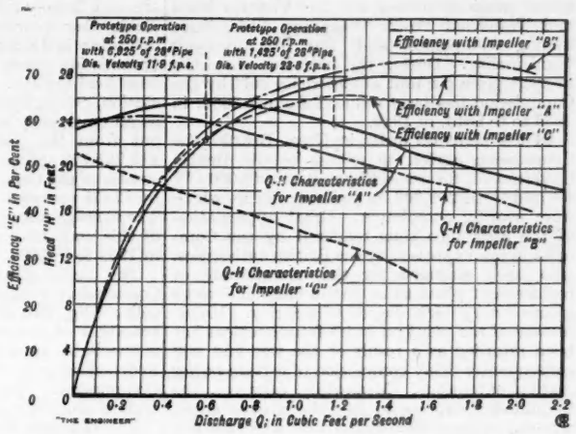
General Conclusions

Outstanding phenomena, brought to light as a result of this visual investigation, are the existence of large deadwater areas within the impeller and the consequent existence of extremely high velocities over a small percentage of the cross-sectional area within the impeller. The magnitude of these velocities is often six times the average for the entire area. On account of these extreme velocities, considerable energy losses occur as a result of the transformation from potential to kinetic energy, and *vice versâ*. It is believed that these losses may be materially reduced by changes in design after further experimental effort.

The phenomena of deadwater areas and maldistribution of velocities are also existent in conjunction with fluid flow through bends in pipes and conduits resulting in extensive energy losses. These influences must be detrimental to the transfer of fluid through the various piping systems of naval vessels, where space is at a premium and elbows, manifolds, and bends are in abundance. The decrease in power requirements and improvement in efficiency of these systems could well offset the cost of further experimental effort in this field.

Many aspects of a broad and rudimentary subject have been discussed in brief. If this paper succeeds in raising more questions than providing answers, thereby stimulating further investigation, the effort expended in its preparation will have been well repaid.


Prototype Operation at 250 r.p.m with 6,925' of 28" Pipe Discharge Velocity 11·9 f.p.s.
Prototype Operation at 250 r.p.m with 1,425' of 28" Pipe Dia. Velocity 23·8 f.p.s.
Efficiency without Tongue Extension
Eff. with Tongue Extension
Q-H Characteristics without Tongue Extension
Q-H Characteristics with Tongue Extension
Total Head in Feet
Efficiency in Per Cent
Discharge: Cubic Feet per Second
"THE ENGINEER"


Prototype Operation at 250 r.p.m with 6,925' of 28" Pipe Dia. Velocity 11·9 f.p.s.
Prototype Operation at 250 r.p.m with 1,425' of 28" Pipe Dia. Velocity 23·8 f.p.s.
Efficiency with Impeller "B"
Efficiency with Impeller "A"
Efficiency with Impeller "C"
Q-H Characteristics for Impeller "A"
Q-H Characteristics for Impeller "B"
Q-H Characteristics for Impeller "C"
Efficiency "E" in Per Cent
Head "H" in Feet
Discharge Q; in Cubic Feet per Second
"THE ENGINEER"

FIGS. 9 AND 10—PUMP CHARACTERISTICS

South African Electricity Supply Commission

The Electricity Supply Commission of the Union of South Africa has just presented its eighteenth annual report, which covers the activities for 1940, and includes also a brief review of the happenings up to March 31st, 1941. For reasons of policy only the salient features of the Commission's activities are dealt with in the report.

Despite war conditions, another record year of developemnt is recorded. The following points emerge from the review:—The total output of electricity from the Commission's generating stations reached the record of 4,176,074,675 units for the year 1940, exceeding

the previous year's output by 11·01 per cent. The year was marked by the fact that the total generating plant capacity of the Committee's power stations in operation, under construction or on order exceeded one million kilowatts. At December, 1940, the plant in operation totalled 782,631 kW, and plant under construction or on order at that date amounted to 238,900 kW, making a total of 1,021,531 kW. The total revenue was £2,861,220, compared with £2,630,473 in 1939. The total production costs (including interest, redemption and reserve fund charges) amounted to £2,858,931. The small surplus of £2289 is a measure of the success achieved in carrying out the general principle laid down in the Electricity Act that the Commission shall, as far as practicable, operate its undertakings neither at a profit nor at a loss. The sales of electricity exceeded the 1939 total by 13·89 per cent. The largest increase, 14·46 per cent., was in respect of bulk supplies to the mines. The total consumption of electricity on the Witwatersrand by the gold mining and other industries and municipalities, &c., exceeded 5,341,000,000 units in 1940 and approximately 66 per cent. was supplied from the Commission's power stations at Klip and Witbank, the balance being supplied from power stations owned by the Victoria Falls and Transvaal Power Company, Ltd., three mining companies and the Johannesburg Municipality. During the past five years the average price per unit of electricity sold by the Commission has been reduced from 0·266d. in 1935 to 0·164d. in 1940.

Of the plant on order in Great Britain, the Commission agreed to release to the British Government, for use in England, one 40,000-kW set and three 200,000 lb. per hour boilers which were nearing completion. Great appreciation of the assistance thus rendered by the Commission was expressed by the British authorities, who have arranged for the manufacture of replacement plant to be put in hand and to be given a very high degree of priority. Manufacture of the plant on order from overseas has been retarded as a result of the war and will consequently delay completion of certain power station extensions. Meanwhile, however, the Commission expects to be able in most cases, without serious difficulty, to meet all reasonable demands of existing consumers, as its policy has always been to plan well ahead of actual requirements as far as possible. War conditions have further delayed delivery of two double-unit mercury arc rectifier plants for sub-stations on the Rossburgh-Hillcrest section of the Natal old main railway line, which is being converted to electric traction. Advice has been received, however, that the equipment has been tested and is ready for shipment.

The last two of the twelve 33,000-kW generating sets installed in the Klip power station were placed in service on January 4th and July 15th, 1940, respectively. To complete the station two more 180,000 lb. per hour boilers are under construction, and when they are installed the total boiler capacity will be 4,320,000 lb. of steam per hour. The station is operated on behalf of the Commission by the Victoria Falls and Transvaal Power Company, Ltd., which takes the whole output for supply to the gold mining industry and other consumers on the Witwatersrand. In 1940 the station sent out 2,566,537,197 units, an increase of 17·02 per cent. compared with the previous year. Klip power station consumed coal at an average rate of 247 tons per hour, at an average price of 3s. 6d. per ton, the total consumption for the year being 2,166,318 tons, at a cost of £379,932. The total capital expenditure on the station at December 31st, 1940, amounted to £6,351,169.

Reports from overseas indicate that the manufacture of the generators for the Vaal generating station is proceeding satisfactorily. The initial installation will be of 100,000 kW. Construction of the circulating water system, including the two hyperbolic cooling towers, each 320ft. high, coaling appliances, railway sidings and staff quarters has been completed, and erection of the steel-frame generator house is in progress.

Development of the use of electricity in rural areas has had to be retarded owing to the difficulty of obtaining the necessary transformer and line material under prevailing conditions, and to the necessity for conserving present stocks for essential supplies. Certain extensions to the Commission's systems were, however, proceeded with in several cases where negotiations had practically been completed on the outbreak of war. The total number of towns and villages supplied with electricity by the Commission in the Union at December 31st, 1940, was 108, being thirteen more than in the previous year, and twenty-nine additional farms were connected to the Commission's systems, bringing the total throughout the Union to 427 at that date.

The consumption of electricity for domestic purposes by consumers supplied direct by the Commission totalled 16,132,354 units and reached the high average of 1660 units per consumer in 1940, compared with 1598 in 1939. The number of local authorities supplied with electricity in bulk from the Commission's undertakings remained unchanged at sixteen at the end of 1940 and their purchases for the year totalled 283,003,601 units.

Under a pooling agreement the electricity requirements of the Commission's Cape Town undertaking and the Cape Town Corporation are now largely generated at the Corporation's Table Bay power station, which came into operation in 1939 and has since superseded the Commission's Salt River power station as the base load station. The old Dock Road power station, owned by the Council, is being retained as an emergency station. The total units sent out from the pooled stations in 1940 were 413,937,772 units. Sales of electricity to consumers of the Cape Town undertaking increased by 12·51 per cent. to 119,770,941 units in 1940. The average price per unit sold to all consumers of this undertaking was reduced from 0·789d. in 1939 to 0·752d. in 1940.

The large electricity undertakings of the Commission number five, viz., Colenso, Congella, Klip, Salt River and Witbank. These are either oil or steam plants. In addition there is the Sabie power station, which is the only hydro-electric generating plant owned by the Commission. There are also several small undertakings with oil plants.

The Witbank and Klip stations are operated by the Victoria Falls and Transvaal Power Company, Ltd., on behalf of the Commission. The Klip power station is the largest of the Commission's undertakings and contains twelve 33,000-kW generators and the total capacity of the plant, including house set, is 424,000 kW. Steam is supplied by twenty-two boilers, their normal rating being 180,000 lb. of steam each per hour, with pressure of 390 lb. per square inch. At December 31st, 1940, the Commission's loan capital totalled £19,484,095, all of which had been publicly subscribed in South Africa. Capital expenditure at December 31st, 1940, was £19,330,832 and expenditure on major works under construction and on minor extensions will bring the total expenditure on capital account to approximately £24,250,000.

The total production of electricity from all undertakings in the Union of South Africa during the year 1940 was 6,574,291,445, compared with 5,932,992,903 in the year 1939. The total units consumed totalled 5,453,437,354. The total number of consumers was 325,437, of which 114,067 were domestic consumers, to whom 626,318,816 units were sold, an average of 2218 each. The total quantity of coal consumed in the production of electricity in the Union was 5,764,275 tons, at a cost of £2,085,955. The total value of land, buildings, machinery, plant and tools engaged in the operations was £45,727,077; total number of persons employed in the electricity industry (generation and distribution) was 16,875, and the total of salaries and wages paid for the year was £2,525,314.

Synthetic Adhesives for Plywood Manufacture

The development and increasing use of synthetic adhesives has been a feature of plastics progress during the past few years. This fact is especially interesting, because glue manufacture is one of the oldest arts, and it seems probable that synthetic adhesives will revolutionise it as surely as synthetic dyes and synthetic paints have revolutionised correspondingly ancient and well-established industries. Enormous quantities of natural glue are still used in the wood-working industries, but there is one important branch—the manufacture of plywood—where in this country at least natural glues have been completely supplanted by synthetic products.

Plywood is made to one of two specifications, either D.T.D. 427 or B.S.S. 5 V 3, requiring resistance to three hours' immersion in water at 60 deg. Cent. and 100 deg. Cent. respectively. At present urea formaldehyde resins are used for D.T.D. 427 plywood and Tego film—paper impregnated with a phenol formaldehyde resin and used in a dry state—for the 5 V 3 plywood. On the whole, the phenol formaldehyde resins are more water resistant than the urea formaldehyde resins. Although the latter can be given sufficient water resistance to meet the three hours' boiling test of specification B.S.S. 5 V 3 by the use of certain modifying agents, they need higher pressures and temperatures to set them than do the urea formaldehyde resins. The ability to set urea formaldehyde resins at room temperatures is of no importance in plywood manufacture, as all the plywood made in this country is made in hot presses.

Although modified urea formaldehyde glues meet the requirements of B.S.S. 5 V 3, they cannot be used in the manufacture of very thin plywood, because of the swelling caused in the thin veneers by the wet glue, and because of the penetration that takes place after subsequent pressing. The phenol formaldehyde film type of glue is immune from these troubles. To meet this difficulty and at the same time to reduce costs, Aero Research, Ltd., of Duxford, Cambridge, has introduced a foamed-modified urea formaldehyde glue which in many respects is claimed to combine the advantages of liquid and dry film glues, with the added advantage of low cost. The idea behind this process is that, provided penetration of the glue into the veneers is obviated, only a very thin film of glue is needed to make good joints. The amount of glue applied by any ordinary means—glue spreaders or brushes—is in excess of the optimum amount. By using the glue in the form of a foam of about the same consistency as the lather produced from shaving soap, an extremely uniform spread, it is claimed, is obtained in terms of pounds of glue per square foot, although the glue layer has an appreciable thickness. Actually, the volume of the glue is about doubled by a special beater machine before it is poured into the glue spreader. Under ordinary factory conditions, without taking any special precautions, it is possible to get a spread of 1·35 lb. of glue per 100 square feet.

This foamed-up glue is known as "Aerolite F.67," and gives plywood which, it is stated, meets the requirements of specification 5 V 3. Because of the nature of the foam, it can be used with thin veneers without producing excessive wrinkling or causing overlaps in the cores. The foam is allowed to dry on the veneers after it has come through the rollers of the glue spreader. It does this very quickly, and, in fact, the film of foam will be found to be dry by the time the veneers have been assembled for pressing. The press temperature required is 90 deg. Cent., so that steam-heated presses are unnecessary, and the older type of press so common in this country with hot-water heating can be used. The use of pressing temperatures below 100 deg. Cent. obviates any risk of overheating of the wood with its attendant troubles.

From a national point of view, this process is of some importance, because it enables two important materials—urea and formaldehyde—to go twice as far as before. J. M. Steel and Co., Ltd., 36–38, Kingsway, London, W.C.2, are the sole distributors of "Aerolite" glue.

A Market of Concrete.—In addition to the main structure, a market hall recently built at Kuala Lumpur, F.M.S., has been fitted with hygienic stalls constructed in concrete in the section where food is displayed. Elsewhere general merchandise is sold over concrete counters.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Iron and Steel in the United States

The iron and steel position in the United States remains tight, although production has been raised to a high figure. The output of pig iron in September amounted to 4,716,900 tons, compared with 4,791,430 tons in August. At the end of the month there were 216 blast-furnaces in operation, compared with 213 on September 1st. The daily production in September was 157,230 tons, against 154,560 tons in the previous month. The output in September averaged 98·8 per cent. of capacity. There have been no price changes, the quotations being :—No. 2 foundry, 20·35 dollars ; Bessemer, 25·00 dollars ; and basic, 19·00 dollars ; but these do not apply to exports to Great Britain made through the British Purchasing Commission and the United States Treasury. The prices at which this business is done are not made public. Tight conditions rule in the scrap market, and all dealings are under strict priority. It is expected that the control will be tightened, and that instructions will be given by the Director of Priorities as to destinations and the quantities delivered to any buyer. It is thought that there is some hoarding of scrap and that further powers will be taken to prevent this practice. It is suggested that mills which are found to be holding larger quantities than they have reported to the authorities will be obliged to surrender their hoard. The control of prices is being drastically enforced and it is reported that a large dealer has already been obliged to refund to buyers all the amounts received in excess of the authorised maximum prices on sales made in September. The steel output has been recently at an average of 98·1 per cent. of capacity, an increase on the 96·9 per cent. which ruled a short time ago. In September the production of steel averaged 96·4 per cent. of capacity and totalled 6,819,700 tons. Production in August reached 7,000,950 tons, and for the nine months of this year ending September 30th the output was 61,550,880 tons.

The Pig Iron Market

No important change has developed in the pig iron market for several weeks. On the whole the situation is satisfactory. Although larger supplies of hematite would be welcome, the position is apparently becoming easier, but the Control still carefully supervises its distribution ; in fact, licences are not granted for this description unless no other make of iron can be used as a substitute. The light castings trade is poorly employed and finds no difficulty in obtaining all the high-phosphoric pig iron it requires. Some of the blast-furnaces in Northamptonshire and Derbyshire have accumulated fair stocks of this kind. Busy conditions rule in the engineering and jobbing foundry trades, which are fully employed upon Government work. It seems likely that the heavy engineering foundries in particular will continue busy for the duration of the war. These foundries are providing a big outlet for low-phosphoric iron and such hematite as can be spared. Consumers, however, have become accustomed to the use of substitutes, so that the tightness in the hematite position does not affect them to the extent it did a few months ago. There is also a strong demand for refined and special irons and the production of these sorts has been well maintained. All grades of pig iron are in steady request in Scotland and all the available blast-furnaces are in full operation. Marine and heavy engineering works which are operating at capacity call for considerable tonnages of low-phosphoric and hematite. Owing to poor employment at the Scottish light castings foundry labour has been transferred to other activities and it is not expected that there will be any increase in the demand for light castings for some time.

The Midlands and South Wales

The steel works in the Midlands are fully employed, but there has been some slight change in the incidence of the demand. For instance, the slackness in business for structural steel is not now so apparent as of late, and in the re-rolling industry there have been signs of a revival in the demand for the lighter sizes of angles, bars, &c. So far as bars are concerned, however, the demand is stronger for the larger diameters and these are being taken up in big tonnages by the heavy engineering establishments. Structural engineers, for the most part, are not working at great pressure ; but, on the other hand, are able to obtain their full requirements at more convenient delivery dates than has been the case for some months. The pressure of demand is chiefly noticeable in the plate department and consumers' requirements show no signs of easing. New business is coming forward in unabated volume and the requirements of the shipyards in particular are heavy. The sheet position also shows some signs of improvement. Business in sheets of medium gauge has expanded, but there is only a fair demand for the thinner gauges. On the other hand, the position has not altered so far as the thicker gauges are concerned and many of the works would be glad to receive more orders. A feature of this section of the industry is the sharp call for special quality sheets. The raw materials position, however, is satisfactory and re-rolling works are obtaining good supplies of semis. The work turned out by the South Wales industry is almost entirely for war purposes, either directly or indirectly. The slackness in the tinplate trade, which is largely due to the restriction of export business by the Government, has created an easier demand for sheet and tinplate bars. Special steels continue in strong demand from the armaments and munition makers.

Scotland and the North

There has been no important change in the conditions of the Scottish iron and steel trade for a long time. All the works are operating at capacity almost entirely upon priority orders. Recently there has been a slight change in the pressure of the demand and the lighter descriptions of steel are in stronger request than others, although there is steady pressure upon all departments of the steel works from consumers engaged on Government work. The cutting out of practically all business of a non-essential nature eased the position at the steel works to the extent that earlier deliveries are now being made against priority orders. With all the marine and other engineering concerns in Scotland fully employed there is a strong demand for special steels, but this has not been accompanied by any falling-off in the consumption of other descriptions. Business in bars has been at a high level for a long time and although in recent weeks there has been some slackening in the demand for small bars of under 3in. diameter, the call for heavy bars has been maintained. The re-rolling industry is not so busy as it was, but production remains at a high level. New business in small bars is quieter, but there is an insistent demand for ferro-concrete rods. The plate position is somewhat stringent, but rather earlier deliveries are possible than was the case a few weeks ago. Large tonnages of this description of steel are passing to the shipyards and their requirements are not likely to decline. Conditions in the Lancashire market have become somewhat easier. Deliveries for the most part are now satisfactory and priority work is dealt with more expeditiously. The consuming trades in Lancashire are practically without exception engaged upon war work and absorb large tonnages of steel. The steel works are operating to capacity and lately there has been a large distribution of imported semis. Business in plates continues at a high level, but there has been no increase in the demand for structural steel. The steel works on the North-West Coast find no decrease in the demand for steel products and all the works are in full operation.

The North-East Coast and Yorkshire

All the steel works on the North-East Coast are pressing production to the utmost. The demand may have developed some easier tendencies during the past few weeks, but this has had little effect upon the activity at the steel works, since they are, for the most part, booked up for a long time. The production of steel ingots is at a high rate and has been expanded recently as a result of the decision to restrict imports from the United States. Another branch which has been speeded up of late and the output considerably increased is that producing billets and sheet bars. Good reserves, however, have been accumulated, particularly of billets and the re-rolling works are in a sound position so far as their raw materials are concerned. Lately there has been some falling-off in the demand for the smaller sizes of bars, and this tendency has also shown itself in the demand for structural steel. Some of the re-rolling works are much less busy than they were and would welcome a revival in business in these descriptions. One of the features of the steel trade has been the sustained demand for plates. The chief consumers continue to be the shipyards, but the tank makers and locomotive builders are also busy and likely to remain so for an indefinite period. The sheet trade, also, is not nearly so busy as it was a few weeks ago. The works, however, have a good volume of orders in hand and in most cases are operating at a high rate, although there are some which would be glad to see a greater volume of business coming forward. Conditions in the Yorkshire iron and steel industry have not changed much for a long time. Production is almost entirely for priority needs and there is an exceptionally heavy demand for alloy and special steels for mechanised equipment. The manufacture of armour plate is on an extensive scale and the demand for the lighter descriptions of steel has been much less vigorous of late. Recently there have been a fair amount of export inquiries, which have been turned down as licences are difficult to obtain.

Copper and Tin

The British copper situation remains satisfactory. The Control carefully supervises the distribution of the metal and at the same time follows a policy of promoting economy in other directions. A higher proportion of scrap is now to be used in the production of certain descriptions of billets and, consequently, a closer supervision is being exercised over the distribution of brass and copper scrap. Although the requirements of the war industries are being fully met, copper for non-essential purposes is difficult, if not impossible, to obtain. There is a big consumption of copper by firms employed upon war work and the brass industry in particular is taking large quantities. At the same time, an attempt to safeguard the future has been made by accumulating some stocks of imported American brass materials. In the United States the position remains practically unchanged. The possibility of a shortage of copper is agitating American consumers, although in this country it is thought that these fears are exaggerated. It is probable, however, that the use of copper will be more and more confined to the requirements of the defence programme. A further purchase of 96,000 tons from South America by the United States authorities is reported. The greater part of this copper is expected to be provided by Chile and delivery is arranged for round the end of the year. Whilst no official statement of the price paid for this copper has been issued, it is believed to be 11¼c., c.i.f. The export of copper from the United States has practically ceased and all available supplies are being severely conserved for the defence programme by the American authorities. . . . Rather uninteresting conditions have ruled in the tin market of late and apparently the authorities in Great Britain and the United States are desirous of maintaining steady conditions. Although nominally the London tin market is the only free metal market in Great Britain, it is in effect little more free than other metal markets. The Government controls the price of cash tin, since it is ready to enter the market when necessary, although probably it would be willing to release tin if any abnormal demand were to spring up. The three months' price is regulated by the big smelters which in turn are practically under Government control. No export licences for tin are being issued, and it is not expected that there will be any change in this policy for some time. The contango remains at about 75s. to 85s.

Lead and Spelter

The lead position in Great Britain is generally described as comfortable. Supplies are reaching this country in greater volume than at one time seemed probable, and although the demand is excessive for war purposes the firms engaged on essential work are receiving all the metal they require. There also appears to be a surplus from which firms engaged in less essential work are supplied to a moderate extent. The American lead situation remains rather tight, but apparently the firms engaged upon defence work are obtaining full supplies. The position as regards ordinary commercial work is not so free and Control arrangements in the United States are apparently firmly administered. Following the recent increase in the price of spelter by 1c., it is expected that the lead quotation will also be advanced, since the producers complain that their costs have considerably increased. In the meantime, however, the quotation for prompt lead remains at 5·85c., New York. . . . A heavy demand for spelter exists in Great Britain, but the arrangements necessitated at the beginning of the war to keep this market supplied appear to have been successful, and although the use of spelter for non-essential purposes is discouraged, the war industries are receiving all the metal they require. Probably the largest user of spelter at the moment is the brass industry, which is taking large tonnages. Galvanisers also are reported to be requiring larger supplies, partly because there has been some improvement in the demand for galvanised sheets.

Notes and Memoranda

Rail and Road

Rolling Stock in the Sudan.—The final figures for 1940 show the rolling stock in service on the Sudan Railway as 140 locomotives, of which 106 were main line engines, 31 steam shunting engines, 1 diesel, and 2 diesel-electric shunting engines; 202 coaching vehicles; and 2461 goods vehicles.

Electrification in Sweden.—Electric working over the northern main line of the Swedish State Railways was extended from Vännäs to Bastuträsk, 69 miles, in August. This raises the electrified route length of the State Railways to approximately 2524 miles. A further 20-mile extension to Jörn is nearing completion.

G.W.R. Mobile Canteen.—The Great Western Railway now has a mobile motor canteen, which can be sent immediately by train to any town on the company's system where feeding arrangements have temporarily been disorganised. The canteen will provide at popular prices snacks and hot and cold drinks to members of the staff, who might otherwise find difficulty in obtaining food.

Indian Railway Reverts to Coal Firing.—Thirty locomotives used for the transport of goods and built by the North British Locomotive Company, Ltd., originally for the G.I.P.R., but transferred to the N.W.R. when the main lines near Bombay were electrified, are to be converted from oil to coal burning. These engines have large fireboxes, and it has been decided to equip them with mechanical stokers.

Petroleum Trains for the Argentine.—Arising out of the expansion of petroleum production in the Province of Mendoza, the Buenos Aires and Pacific Railway Company has acquired 300 tank wagons for the transport of crude petroleum from the Mendoza oilfields to the refinery at San Lorenzo, in the Province of Santa Fé. The trains are commonly made up of twenty-two tank wagons, each with a capacity of 41 tons, giving a total capacity of approximately 900 tons a train.

Brazilian Economies.—The Rio Grande do Sul Railway, which belongs to the Federal Government, but is leased to the State of which it bears the name, has had difficulty in obtaining new rails, and its engineers are now cropping each end of the rails suffering from wear and batter at the joints. This has proved unsatisfactory, and a deputation of engineers is visiting the U.S.A. with a view to ordering a butt welding plant and also any additional rails that can be made available.

Air and Water

Sweden's Loss of Tonnage.—It has been disclosed that up to the end of June ninety-nine Swedish merchant ships totalling 264,830 gross tons had been sunk as a result of the war, and twenty-six merchant vessels of 46,923 gross tons had been seized by belligerents.

Aircraft Plywood.—The Standards Association of Australia has issued a specification for aircraft plywood. For about five years past aircraft plywood has been manufactured, the first timber used for the purpose being the native species of coachwood, but it is likely now that other kinds have been found suitable. The specification deals with general provisions for all plywood, minimum requirements for structurally unimportant parts, and for structurally important parts of the aircraft. Appendices give figures on thicknesses and tolerances, moisture content, resistance to water, bending properties, and tensile strength.

The Anchorites Trafalgar Day Luncheon.—The First Lord of the Admiralty, the Right Hon. A. V. Alexander, was the principal guest at the annual Trafalgar Day luncheon of The Anchorites, which took place at Oddenino's Hotel on Tuesday, October 21st. The chair was taken by the President, Admiral Sir Reginald Tupper, and the guests included several members of the Board of Admiralty, the Naval Attachés of the Allied and friendly Navies, and many representatives of shipping, shipbuilding, and maritime interests. Replying to the principal toast of "The Board of Admiralty," the First Lord paid a warm tribute to the increasing assistance which was being rendered at sea to the common cause of freedom by the small but highly efficient navies of our Allies. He spoke of the magnificent leadership of Mr. Winston Churchill, the Prime Minister, and the unfailing support he had at all times received from the First Sea Lord and the Naval Staff at the Admiralty. The complete confidence he had in their abilities and judgment had convinced him, he said, that the standard of the Navy to-day was on a level with the most glorious period of its long history. Admiral of the Fleet Sir Dudley Pound, the First Sea Lord, suitably replied on behalf of the guests.

Miscellanea

Hard Coke.—The British Hard Coke Association has been formed, and will advise the Mines Department. An Executive Committee has been appointed, of which Mr. Ralph Alsop, director and general manager of the Consett Iron Company and chairman of the British Coke Export Sales Corporation, is chairman.

Small Spares Made by Women.—In order to encourage the flow of female labour into works after intensive training, there has been held at the Queen's Hotel, Birmingham, an exhibition of the production of many small parts. The work was carried on by batches of girls and women drawn from various local factories.

The Late Mr. Herbert White.—We regret to have to announce the death, on October 10th, of Mr. Herbert White, one of the partners in R. White and Sons, Railway Engineering Works, Ditton Road, Widnes. Mr. White had been connected with the firm for over fifty years. The business, we learn, will be carried on as usual by the remaining partner, Mr. J. W. White.

Old Maudslay Men.—It is desired to obtain the names and addresses of all engineers or others who were connected with Maudslay, Sons and Field, Ltd., of Lambeth and East Greenwich, with a view to holding a regular yearly meeting. Those who are interested are requested to communicate with Mr. W. H. A. Robertson, Lynton Works, Bedford, who will advise them of developments.

Federation of Manufacturers of Contractors' Plant.—It is announced that manufacturers of contractors' plant have formed the Federation of Manufacturers of Contractors' Plant for the purpose of representing their common interests in dealing with major problems arising from the war and in preparation for post-war conditions. Information can be ob ained from the Secretaries, Messrs. Binder, Hamlyn and Co., River Plate House, 12 and 13, South Place, E.C.2.

Wartime Building Bulletin No. 17.—A new Wartime Building Bulletin, No. 17—"Resistance of Reinforced Concrete Structures to Air Attack," published by H.M. Stationery Office, price 6d. net—has been issued by the Building Research Station of the Department of Scientific and Industrial Research. Evidence obtained from an extensive survey of damaged structures shows that modern reinforced concrete structures of good design stand up remarkably well to high-explosive and fire, but that certain precautions may be taken in design which increase the resistance of the normal structure to air attack without any appreciable increase in cost. The Bulletin, which was prepared with the assistance of Mr. W. L. Scott, M. Inst. C.E., M.I. Struct. E., contains a list of these precautions, intended for the use of architects and engineers working on the design of wartime buildings.

Personal and Business

Mr. W. C. Lusk has been elected chairman of Ferguson, Pailin, Ltd.

Mr. I. A. R. Stedeford has been appointed a director of Stewarts and Lloyds, Ltd.

Mr. J. A. Milne has been appointed managing director of J. Samuel White and Co., Ltd.

Mr. A. Moller, chief engineer of Peter Lind and Co., Ltd., has been appointed to the board of the company.

Mr. J. E. Raistrick has been elected President of the British Association of Used Machine Tool Merchants.

Major H. M. Lawrence has been appointed Director of Traffic Requirements for the Ministry of Works and Buildings.

The Ministry of Supply announces that Messrs. H. V. Bonar and T. D. Bruce have been appointed Deputy Controllers of Jute.

The Institution of Mining and Metallurgy has changed its address to temporary offices at the Royal School of Mines, London, S.W.7.

The Institution of Automobile Engineers informs us that Mr. J. Shearman has been elected Chairman of the Automobile Research Committee for 1941–42, in place of Mr. W. A. Tookey, whose appointment to a post at the Ministry of Supply has necessitated his resignation of the chairmanship. Mr. A. G. Benstead has been elected Vice-Chairman of the Committee in place of Mr. G. Lanchester.

Mr. John Brown has resigned from the Industrial and Export Council and Mr. George Chester has been appointed to the Council in his place.

J. Samuel White and Co., Ltd., announce that Mr. J. A. Milne, M.I.N.A., has been appointed managing director of the company. Mr. Milne joined the firm in February last, when he was appointed general manager.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that in order to make sure of its insertion the necessary information should reach this office on or before the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Bradford Engineering Society

Monday, Nov. 10th.—Technical College, Bradford. "Theory and Practice in Strength of Materials," J. G. Jagger. 7.15 p.m.

British Association of Refrigeration

Thursday, Nov. 6th.—Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. Presidential Address, S. F. Dorey. 3 p.m.

Institute of Fuel

Thursday, Oct. 30th.—Connaught Rooms, Great Queen Street, W.C.2. "Liquid Pitch Fuel," E. Brett Davies. 2.30 p.m.

Institute of Metals

Wednesday, Oct. 29th.—Engineers' Club, Albert Square, Manchester. "Causes of Porosity in Tin-Bronze Castings," T. F. Pearson and W. A. Baker. 4.30 p.m.

Institute of Transport

Saturday, Oct. 25th.—Metropolitan Graduates. Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Address by the President, J. S. Nicholl. 2.15 p.m.

Institution of Chemical Engineers

To-day, Oct. 24th.—Institution of Civil Engineers, Great George Street, S.W.1. "Scientific Knowledge and Action," Sir Richard Gregory. 2.30 p.m.

Institution of Civil Engineers

Saturday, Nov. 8th.—N.W. Assoc.: Engineers' Club, Albert Square, Manchester. "Road Experiments on the Design of Thin Bituminous Surfacings," R. Slater. 2.30 p.m.

Institution of Electrical Engineers

To-day, Oct. 24th.—N.E. Students: Neville Hall, Westgate Road, Newcastle-upon-Tyne. Chairman's Address, "Units," E. Jeffrey. 6.30 p.m.

Saturday, Oct. 25th.—N. Midland Students: Hotel Metropole, King Street, Leeds. "Choice of Three-phase Industrial Motors," A. E. Cunniagham. 2.30 p.m.

Saturday, Oct. 25th.—S. Midland Centre. Grand Hotel, Birmingham. Wartime Luncheon. Chairman's Address, R. H. Rawll. 12.30 for 1 p.m.

Monday, Oct. 27th.—N.E. Centre: Neville Hall, Westgate Road, Newcastle-on-Tyne. "Outdoor Bushings—their Construction, Testing and Standardisation," W. A. Cook. 6.15 p.m.

Institution of Mechanical Engineers

To-day, Oct. 24th.—Storey's Gate, Westminster, S.W.1. Presidential Address, "The Position of the Locomotive in Mechanical Engineering." W. A. Stanier. 2.30 p.m.

Iron and Steel Institute

Wednesday, Oct. 29th.—Rational Hall, Alexandra Street, Ebbw Vale, Mon. "The Annealing of Mild Steel Sheets," C. A. Edwards. 7 p.m.

Junior Institution of Engineers

Saturday, Nov. 8th.—39, Victoria Street, S.W.1. "Mills and Mill Gearing," R. Wailes. 2.30 p.m.

Manchester Association of Engineers

Saturday, Oct. 25th.—Engineers' Club, Albert Square, Manchester. "Economic Planning of a Modern Store," J. S. Beaumont. 2.30 p.m.

Saturday, Nov. 1st.—Reynolds Hall, College of Technology, Manchester. "The Water Grid," A. E. L. Chorlton. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, Oct. 31st.—Mining Institute, Newcastle-upon-Tyne. "Merchant Sea Power, 1919–1939," Sir Westcott S. Abell. 6 p.m.

North of England Institute of Mining and Mechanical Engineers

Saturday, Oct. 25th.—Neville Hall, Newcastle-upon-Tyne Presidential Address, T. R. Ridpath. 2 p.m.

Royal Society of Arts

Wednesday, Nov. 5th.—John Adam Street, Adelphi, W.C.2. "Co-operation for Production," Sir E. Crowe. 1.45 p.m.